STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D. NORDENHOLT, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

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STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

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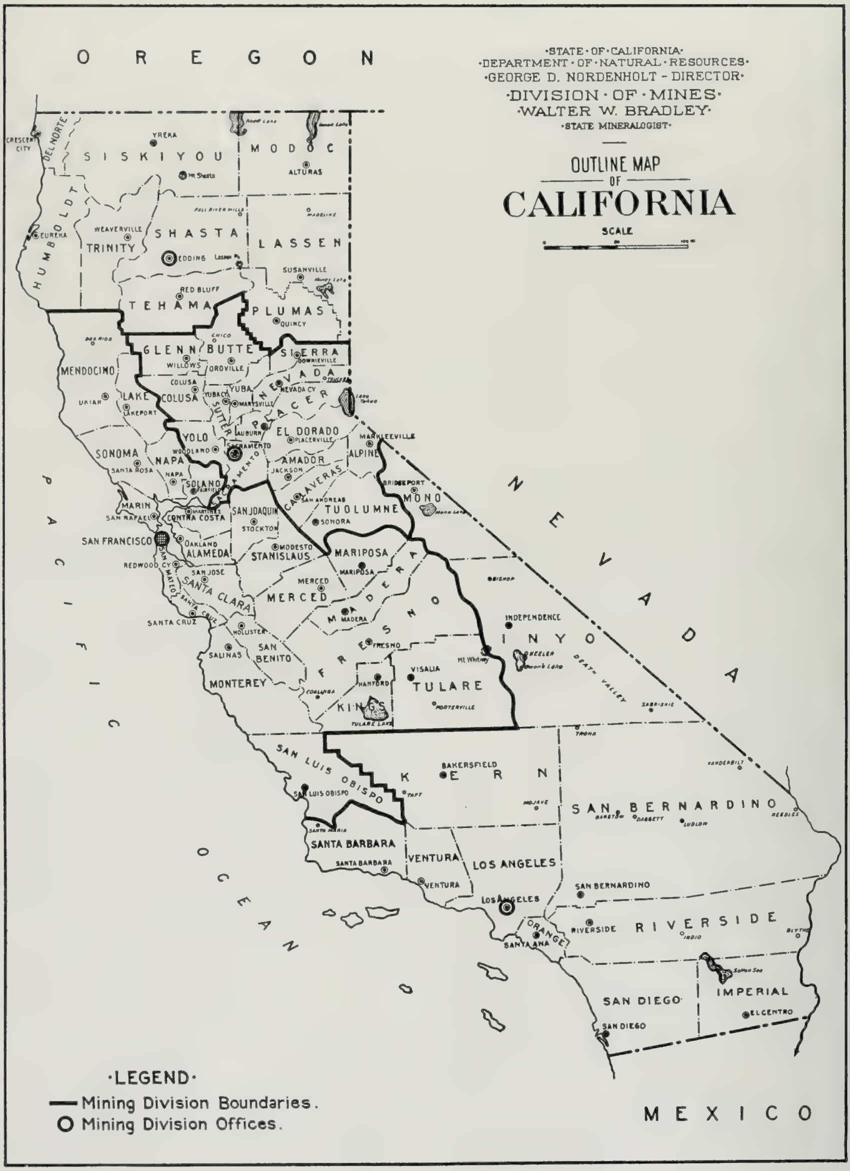
·STATE·OF·CALIFORNIA·
·DEPARTMENT·OF·NATURAL·RESOURCES·
·GEORGE D. NORDENHOLT – DIRECTOR·
·DIVISION·OF·MINES·
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·STATE MINERALOGIST·
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PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to California Journal of Mines and Geology, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).
2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).
3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919-1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

CHAS. VOLNEY AVERILL, Mining Engineer

There is no report from the Redding Field District on account of unfinished field work.

SACRAMENTO FIELD DISTRICT

C. A. LOGAN, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. LAIZURE, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field Division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

W. B. Tucker and R. J. Sampson, Mining Engineers

MINERAL RESOURCES OF SAN DIEGO COUNTY

By W. B. Tucker and Charles H. Reed*

Foreword

The accompanying report has been prepared from data and information gathered by the authors, who were assisted by field workers of a WPA project which was sponsored by the board of supervisors of San Diego County. For twelve months during 1936 and 1937 they inspected and reported on 325 mining claims and quarries in the county. The information thus obtained was entered on questionnaires which had been prepared by the Bureau of Mines of San Diego County. For data regarding mines that were flooded and impossible to enter at the time of the survey, resort was made to former reports of the State Division of Mines, supplemented by information furnished by owners of the properties. A final field check on operating properties was made by the senior author late in 1938.

Primarily, the main objective of this report is to indicate present and potential mining activities in San Diego County. Occasional reference has been made to events of historic interest. For detailed information on the geological and physiographical features of the county, the reader is referred to exhaustive reports which have been previously published, mention of which is made later.

In the preparation of the manuscript and the compilation of statistics presented in this report, workers of the WPA Federal Writers' Project and the National Youth Administration collaborated with the Bureau of Mines of San Diego County.

Introduction

The area was first explored by white men in 1542, when Juan Rodriguez Cabrillo, a Portuguese, sailing under the Spanish flag, anchored his ship in the channel which washes the southern shore of Point Loma. It was here that the first of the missions of Alta California under jurisdiction of the Franciscan Fathers was established in 1769, more than 200 years following Cabrillo's explorations. When, by the terms of the treaty of Guadalupe Hidalgo, control of the territory passed to the United States in 1848, it automatically became the most southwesterly county in the nation. From mineralogical viewpoints, it has perhaps the largest variety of mineral deposits of any area of like size in the United States and the fourth largest deposits of semiprecious stones known to exist in the world.

Originally, as one of the twenty-seven counties organized in the State of California, San Diego County was the largest of the group. From the Pacific Ocean, it extended east to the Colorado River. Its western boundary followed the ocean north from the international boundary to the mouth of San Mateo Creek, thence followed that creek to its source, and thence the line ran straight north to contact the

*Mining engineer, Bureau of Mines of San Diego County.

diagonal boundary line of Nevada. After the meeting of the first state legislature in 1851, a large area was separated to form most of San Bernardino County and the eastern third of Inyo County as now geographically defined.

Subsequently, in 1889, its area was again reduced by the organization of Riverside County, and in 1907, by the organization of Imperial County. Its present eastern boundary is marked by the meridian defining R. 8 E., and its northern boundary is marked by the line defining T. 9 S., S. B. M. However, at the northwest corner an irregular boundary line jogs northerly to include several sections of land lying north of the T. 9 S. line.

The present land area of the county is 4221 square miles. Estimated population (1938), 250,000. County seat, San Diego.

Resources of San Diego County

In the evolution of its present economic development San Diego County has passed through various stages. For about thirty years following secularization of the missions in 1832, resulting in the granting and sale of large tracts of land to the Mexican military and political leaders, the principal industry was stock raising. Cattle were raised chiefly for the hides and tallow. Then came the agriculturists and orchardists. It resulted in the enactment of state laws which required the ranchers to fence their lands, except in isolated districts, forcing many of them into other lines of endeavor. The discovery of quartz gold in the Julian district in 1870 created a new source of wealth and brought a corresponding wave of immigration. Eventually, the development of other resources, including its seacoast and climatic advantages, have rapidly brought the county into foremost rank in the state.

In San Diego today, one of its important and fast-growing industries is the manufacture of aircraft and aircraft parts. Commercial fishing for canning and for the markets is another important industry. Development of the city and its environs for naval activities, and its increasing popularity as a center for tourists and retired classes add materially to the income of the region.

Though San Diego County is not especially noted as an agricultural region, its income from agrarian pursuits amounts to millions of dollars annually. The leading products, in definitely outlined segregated areas, are citrus fruits, deciduous fruits, bulbs, avocados, honey, and live stock.

Mining is a potentially valuable resource of San Diego County. Metals, semiprecious gems, feldspar, silica, granite, and clays are included. Though mining activities have been curtailed during the recent years of financial depression, the present production adds materially to the wealth of the state. In spite of economic conditions nationally in recent years, the annual mineral production of San Diego County has been an average of approximately $600,000.

However, the areas open to mining are restricted by exemptions resulting from Indian reservations, state parks, and the reservation of mineral rights on several old Spanish land grants. In the county there are twenty Indian reservational tracts covering an area of 114,000 acres, located largely in mountainous and mineralized areas. Anza

Park, said to be the largest state park in the world, is open to mining exploration.

Transportation

San Diego city and county are served by rail lines of the Santa Fe and San Diego & Arizona Eastern systems. Northbound, the Santa Fe line follows the coast to San Onofre, thence to Los Angeles. A branch line from Oceanside taps the citrus districts surrounding Escondido, and another branch from Los Angeles Junction serves the district of Fallbrook and vicinity. A branch of San Diego & Arizona Eastern line runs from San Diego to Lakeside.

Improved automobile highways provide access to all producing districts of the county. U. S. 101, from the north, enters San Diego County near San Onofre, continues to and through San Diego city and on to Tiajuana, Mexico, where it connects with an improved highway to points farther south. Its capacity is ample to accommodate the heaviest overland transportation of this period. U. S. 395 is an improved inland highway connecting San Diego and Los Angeles, via Escondido, Riverside and other intermediate points. U. S. 80 or State 73, known as 'Lee Highway,' directly connects San Diego with the Imperial Valley and eastern points. Connecting the various trunk lines are improved secondary highways throughout the county.

Physiography

The topographic features of San Diego County have been described as a "series of parallel ranges of granite, with a southeast trend, including the southeastern continuation of the San Jacinto Range of Riverside County." Between the granite peaks are valleys in which appear belts of slate and mica schist, with occasional quartzite and limestone. In a northwesterly direction these belts extend from Mexico into Riverside and Orange counties. The trend of the Cuyamaca and Laguna ranges, which frequently reach an elevation exceeding 5000 feet, is in a northwesterly direction. Diorite and gabbro occur at frequent intervals. West from the granite area is a belt of felsite, which, with a few outstanding peaks—San Miguel, Otay and Black Mountain, for example—is buried beneath mesa formations. The mesas slope seaward from elevations of 300 to 500 feet. Toward the east the divide slopes precipitously to the below-sea levels of Imperial Valley.

Geology

For detailed information on the geology of San Diego County the reader is referred to "Geology and Mineral Deposits of the Julian District," by Maurice Donnelly, issued in Report XXX of the State Mineralogist; Water Supply Paper No. 446, U. S. Geological Survey; W. A. Goodyear in the Eighth Annual Report of the State Mineralogist, pp. 515-528, for the year 1888; Harold W. Fairbanks, in the Eleventh Report, pp. 76-120, for the year 1892; Dr. F. J. H. Merrill, in the Fourteenth Report of the State Mineralogist, pp. 637-645, for the years 1913 and 1914. In this present report the main objective is to place on record the result of more recent investigations and findings, as they may apply to present conditions and potential future developments.

The formations of San Diego County are granites and other igneous crystalline rocks, metamorphic strata of great age, sandstones, shales, conglomerates, sands, gravel and clays of the Mesozoic and Tertiary age.

The granites are intruded by basic rocks of the diorite and gabbro types. The latter are cut by pegmatite dikes, which also appear in the schists and granites. Massive examples of such intrusions are three peaks of the Cuyamaca range, the highest of which, Cuyamaca Peak, reaches an elevation of 6515 ft. Laguna Peak, 10 miles southeast, is a ridge of diorite, its summit attaining an altitude of over 6500 ft.

Southwest of the granite area is a volcanic flow, extending about 40 miles northwest from Mexico. It is overlaid to a large extent by deposits of the Tertiary period. Felsite, tuffs and volcanic conglomerates are exposed. The metamorphic formations are mica schists, slates, quartzites and limestone. The oldest rocks recognized in the Julian-Banner District are meta-sedimentary mica schist and quartzite, possibly of the Jurassic Age. The sediments of that period were initially marine shales, argillaceous sandstones and pure sandstones. Almost all the gold-bearing quartz deposits are in schist and practically all are enclosed, in whole or in part, in a single body of schist which extends for a distance of twelve miles, with an average width of one mile. The future of gold mining operations in the area will depend on the adoption of modern mining and milling methods. The Cretaceous strata of the region also appear in the bluffs of Point Loma and La Jolla. They are described by Harold W. Fairbanks in the Eleventh Report of the State Mineralogist, p. 95.

Tertiary or Eocene deposits are exposed from Los Peñasquitos Canyon northward to Buena Vista Creek and southward from the same point to Mexico. The earlier deposits of that nature are underlaid by layers of shale, sandstone, clay, limestone, marl, and calcareous material.

METALS

ARSENIC

Arsenic is found in a number of localities in San Diego County in the minerals arsenopyrite (FeAsS) and scorodite, an oxidization product of arsenopyrite. The principal occurrences noted were in the Black Mountain and the Laguna districts. At the Black Mountain Mine, located southwest of Escondido, some development has been done and an attempt made to make a commercial product by concentration.

Black Mountain Group is located in Sec. 5, T. 14 S., R. 2 W., S. B. M., 9 miles southwest of Escondido on the north slope of Black Mountain; elevation 1000 ft. Holdings consist of 4 claims, a total of 80 acres; owner, Mrs. Sarah E. Wylie, 2008 Fremont Ave., Los Angeles.

The ore occurs as arsenoyprite, in two parallel dikes of quartzite that cut the diorite, with a general northwest strike and dip to the northeast. These dikes are from 10 to 15 ft. wide. The arsenopyrite, associated with pyrite, occurs in the form of lenses and also is finely disseminated throughout the fractures and seams in the quartzite.

Development consists of a tunnel 30 ft. in length, 2 shafts 40 ft. deep, and a number of opencuts made along the outcrops of the quartzite dikes. The mine run of ore extracted from the tunnels is reported to average 5% arsenic, with from \$2 to \$5 in gold per ton. This property when formerly worked is said to have produced a concentrate carrying 40% arsenic.

The equipment formerly installed has been removed, and the property is idle.

Arsenic also occurs as arsenopyrite in the quartz veins of the *Willhite Group* of claims, located on the west slope of the Laguna Range, about nine miles east of Descanso; also in the gold veins in the Julian District.

BERYLLIUM

Aside from the gem varieties of beryllium found in the gem deposits in San Diego County, there recently have been discovered commercial deposits of the ore in the pegmatites 2½ miles northeast of Vista. Metallurgical tests over an extended period on the ores of this region are reported to show a 3 to 5% beryl content. Prospecting is now under way in the district in search of more extensive deposits.

Beryllium alloyed with other metals—copper, steel, aluminum, etc.—materially increases their tensile strength. In the case of copper, electrical conductivity and hardness are increased. It is also used in the manufacture of certain ceramics.

Extensive search for commercial deposits of this ore are being made throughout the world. If found, the present high cost of pro-

ducing the oxide and the manufacturing of the pure metal could be materially cheapened.

Mountain Bell Mine. It comprises 160 acres of patented land situated in Sec. 8 and 9, T. 11 S., R. 3 W., S. B. M., 4 miles northeast of Vista; elevation 1200 ft.; owner, Edward Hogerman, Vista, Cal.; under lease to Beryllium Alloys Company, W. E. Schoppe, president; Edgar R. Larsen, chief chemist; Arthur G. Imhoff, superintendent, 625 Market Street, San Francisco, Cal.

Beryl occurs in a pegmatite dike which has a strike of NW.-SE., in granite. The vein material is principally silica, feldspar, tourmaline and mica. The feldspar sheen shows faint blue color which indicates beryllium, in the form of bertrandite.

Development consists of opencut 60 ft. in length by 20 ft. in width; also tunnel on pegmatite vein 40 ft. in length. Idle.

BISMUTH

The ores of bismuth are not found in commercial quantities in the county. It occurs native and as the oxide associated with the lithia ores at Pala.

COPPER

Copper minerals occur in association with ores of other metals quite extensively throughout the county but no large deposits have as yet been developed. This metal has been found at several points in the hills, between Escondido and Encinitas.

On the San Vicente Grant, copper minerals occur in a mineralized zone on contact of granite and schist. Surface croppings show brown oxides of copper, malachite and some azurite. Below the oxidized zone, a sulphide zone was encountered, and chalcopyrite associated with pyrite is finely disseminated throughout the schist. This deposit was formerly known as the *Barona Mine;* now known as *Daley Copper Mine.*

Chalcopyrite, carrying gold, has been found in small quantities on the east slope of Barker Mountain, northeast of Dulzura. Southwest of Julian, the Friday Copper Mine shows a small percentage of copper sulphides and carbonates along the gossan outcrop.

Daley Copper Mine (Barona Mine) comprises 100 acres of patented land located in Sec. 11, T. 13 S., R. 1 E., S. B. M., 7 miles southwest of Ramona; elevation 1650 ft.; owner, Sarah M. Daley, San Diego, Cal.; under option to the *Southern California Mining & Smelting Co.;* George W. Lindsay, president; J. W. Ott, secretary; M. W. Tanner, superintendent, San Diego.

This deposit was discovered in 1894 and operated from 1915 to 1916 by the *San Jacinto Mining & Milling Co.* In 1916 it was bonded to the Southern California Mining & Smelting Co., of San Diego, who operated the property until December, 1923, and then after a short shut-down, resumed operations.

A mineralized zone about 150 ft. in length by 50 ft. in width occurs on a contact of granite and schist. Surface croppings show brown oxides of copper, malachite and some azurite. The oxidized zone has a depth of 30 ft. Here the sulphide zone was encountered.

The ore occurs as chalcopyrite associated with pyrite and is finely disseminated throughout the schist. It is stated that the ore mined will average from 2 to 3% copper, with 6 oz. silver. The mineralized schist is cut by a porphyry dike 12 to 15 ft. wide which strikes N. 50° E., with a dip of 70° NW.

Development consists of a vertical shaft 115 ft. deep. A crosscut tunnel driven southeast 50 ft. connects with the shaft below the surface.

Mine equipment consists of a 12 h.p. gas engine hoist, 4½-in. by 4½-in. Rix compressor, cars and air drills. The company is installing a 50-ton concentration plant. Five men are employed.

Bibl.: State Mining Bureau Bull. 50, p. 345; State Mineralogist's Rept. XX, p. 370.

Encinitas Copper Mine. The holdings of this company consist of 20 patented claims located in Sec. 32 and 33, T. 12 S., R. 3 W., and Sec. 4 and 5, T. 13 S., R. 3 W., S. B. M.

This mine was formely worked by the Encinitas Copper Co., of San Diego. The vein is 3 to 8 ft. wide, consisting of a yellowish and black gouge between walls of dark-colored porphyry. The ore is chalcopyrite, associated with pyrite. Strikes NW. to SE. and dips at an angle of 20° to the west.

Development consists of two shafts 200 ft. apart, one 280 ft. deep, the other 100 ft. deep. There are two open-cuts on the vein and one tunnel 60 ft. has been extended into the hill.

Bibl.: State Mineralogist's Rept. XXI, p. 331; Bull. 50, p. 344.

GOLD

History of the Julian District

The gold mining activities in San Diego County center in the Julian-Banner District, located about 55 miles east of north of the city of San Diego, on an improved highway.

Early-day events in the district are more traditional than a matter of history. Original settlers of the region have passed to their reward and it is now impossible to obtain first-hand information regarding the earliest mining activities in the region. Some placer mining had been done in Coleman Creek and nearby localities before the discovery of the gold-bearing ledges. Evidence of it is supported by entries in Record Book 'A' of the Julian Mining District, in the recorder's office of San Diego County. They state the district was organized February 15, 1870, "at a meeting of the miners of Julian." That was one week before the discovery of gold on the Washington claim, February 22, 1870. The first filing on a quartz claim in the Julian Record Book 'A' is that of D. D. Bailey and seven others to cover a property they named 'Warrior's Ledge'. It is dated February 20, 1870, two days before the reported date of the discovery of Washington claim.

Within six months after the discovery of the Washington claim, the filing of 54 claims had been accepted by M. S. Julian, Recorder of the Julian District. They included the Washington, the Owens, High Peak, Van Wert, San Diego and many others.

As news of the discovery spread, prospectors and miners rushed to the region. Drury D. Bailey laid out a townsite on land on which he had filed timber and grazing claims. He named it Julian, after his cousin, M. S. Julian, with whom he and other young men of the Bailey and Julian families had come from Georgia. Soon the town of Julian had a population of 700 and from 1870 to 1880 it was an active mining center. For a time the Wells Fargo Express Co. maintained an office at Julian to care for gold shipments.

Ready Relief Mill, Julian District, San Diego County.

In the fall of 1870, Louis Redman, working on a grubstake furnished by D. D. Bailey, discovered gold in the area then known as San Felipe Canyon. He marked it with a small, American flag and therefrom the town of Banner derived its name. By terms of the grubstake, Bailey filed on the adjoining claim. Subsequent filings by the same parties created the property since known as the Ready Relief-North Hubbard Group, one of the most productive properties of the region.

On the North Hubbard claim, Bailey built a 10-stamp mill which he operated by water power. Water for the mill was obtained from a large spring at an elevation of 700 ft. on the mountain-side. It was conveyed to an undershot water wheel by a 5-in. iron pipe, and furnished ample power for the mill. The old mill and water wheel remained intact until about 1935.

Production in the Julian-Banner District reached its peak in 1874 and thereafter, rapidly declined. Production for the years 1870 to 1876 is not available as the State Mining Bureau had not been organized and there was no public officer authorized to keep a record of existing conditions. Reports on mining conditions in San Diego County, by

Dr. R. W. Raymond, acting for the federal government as U. S. Commissioner of Mining Statistics, begin with his third report in 1871. It is estimated that from 1870 to 1880 the gold production of the Julian-Banner District exceeded $2,500,000. Much of the gold first taken out was sold to manufacturing jewelers.

As stated previously, the reader is referred to various authorities, cited, for detailed geological description of the Julian region.

It is essential to state that several land grants and the Santa Ysabel, Cosmit and Inaja Indian reservations are located in the vicinity and are not open to mineral explorations. Knowledge of these conditions is important to those who desire to prospect in the region.

Bibl.: State Mineralogist's Reports VI, Pt. 1, pp. 85-87; VIII, pp. 513-519; IX, pp. 143-147; X, pp. 541-544; XI, pp. 376-381; XII, pp. 237-243; XIII, pp. 331-347; XIV, pp. 653-655; XXI, pp. 331-332; XXX, pp. 331-370.

GOLD PLACERS

Since the last report made on the mines of San Diego County (July, 1925 quarterly) several attempts have been made to exploit known placer ground, notably the placers existing in Garnet Canyon and the ground on the west portion of the Mykrantz Ranch on the San Vicente Grant. Production 1925 to 1930 was $14,500 in gold.

In both cases the operations were unsuccessful financially, owing to scarcity of water, adobe condition of ground and in the case of Garnet Canyon, lack of dump space and the presence of large boulders. Operation in both places was suspended.

Ballena Placer

Bibl.: State Mineralogist's Reports XI, pp. 91-92; XXI, pp. 332-334.

Coleman Creek Placers. These placers were worked from 1870 to 1880 and it is reported that considerable gold was recovered. The present operations are on the Robert Anthony Ranch, on Coleman Creek, 2 miles east of Julian; elevation 4000 ft. The property is under lease to Dan Lomax and Giles Taylor, Julian, Calif.

These parties intend to work 1000 feet along Coleman Creek, and tests made are reported to carry 35 cents per cu. yd. in gold. The gold recovered has a fineness of 978.

Equipment consists of 4-in. Sterling suction pump, mounted on a raft. The pump is driven by 14-h.p. Ford auto engine. Material handled by suction pump goes to sluice boxes lined with burlap which is covered with $\frac{1}{4}$-in. screen. Later, they plan to install dragline. Two men are employed.

GOLD LODES

Mines and Prospects

Barbara Worth Mine is owned by P. M. Reidy, 4063 Ingraham St., Los Angeles, and is located in Sec. 13, T. 15 S., R. 4 E., S. B. M.

On this claim is a 6-ft. vein of quartz showing values in gold. Workings consist of 70-ft. shaft and a 50-ft. tunnel.

Bill Hills Mine is owned by D. Wilkins, Campo, Cal. It is located in the SW¼ of SW¼ of Sec. 9, T. 18 S., R. 5 E., S. B. M.

On this property gold occurs in quartz and porphyry. Values are in quartz stringers. Workings consist of an 80-ft. shaft and a 30-ft. crosscut. Equipment consists of windlass, bucket, and an 8-ft. arrastre.

Boulder Creek Group is owned by Sprigg Estate, San Diego, Cal. It is located in Sec. 9 and 10, T. 14 S., R. 3 E., S. B. M.

This patented tract, containing 148 acres, is located 14 miles southwest of Julian on the Boulder Creek Road. It comprises the Contact, Yellowstone No. 1, No. 2 and No. 3, the Royal Gorge, Royal Gorge No. 1 and Gold Anchor claims. The vein occurs in a narrow belt of schist in the granite. It strikes N. 30° W., dips 80° W., and has an average width of 3 ft. The ore-shoots are from 20 to 30 ft. in length, the quartz showing free gold, associated with pyrite and arsenopyrite. Values said to be \$6 to \$12 per ton. There are 2500 ft. of tunnels on the group. One shaft 50 ft. and one shaft 12 ft.

Bibl.: State Mineralogist's Rept. XXI, p. 334.

Coarse Gold Mine is owned by Donald Wallace. It is located 14 miles southwest of Julian on Boulder Creek Road, in Sec. 2, T. 14 S., R. 3 E., S. B. M.; three claims.

On these claims there is an 8-ft. stringer vein in schist. Development consists of a shaft 80 ft. deep and a tunnel 25 ft. long. Equipment includes one drill compressor operated by gas engine. Idle.

Coe Mine is owned by D. H. Coe, El Cajon, Cal. It is located one mile southeast from El Cajon, on the Chase Ranch.

This claim has a 4-ft. vein of quartz carrying free gold. Workings consist of a shaft 50 ft. and a drift 45 ft. Equipment consists of one-stamp mill, 4-ft. arrastre, gallows-frame, hoist and pump for dewatering the mine. Intermittently worked.

Donohoe Group. This group is owned by Steward Donohoe, Mrs. Linnet Thing and Mary Donohoe, Dulzura, Cal. The property is located in Sec. 16, 21 and 22, T. 18 S., R. 2 E., S. B. M., and comprises 6 patented claims situated in the Dulzura District.

A series of parallel veins occur in granite. Development consists of a tunnel 260 ft. in length driven on Golden Chief vein. On the Sulphide claim, a tunnel has been driven 200 ft. on the vein. On the Golden Artery Claim there is a crosscut tunnel of 372 ft. in length; also numerous shafts, trenches and open-cuts. On Comet Claim there are 4 parallel quartz veins. The ore shows free gold associated with pyrite. Idle.

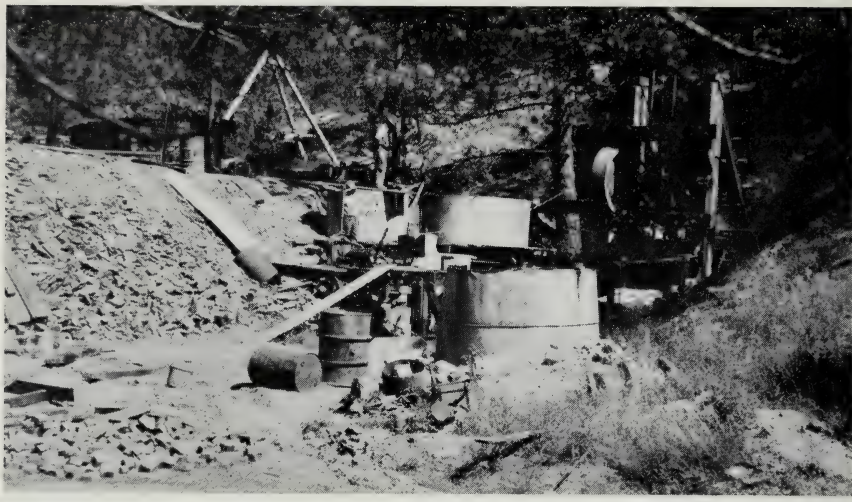
Eagle Mine comprises one claim; owned by A. P. Frary, Julian, Cal. It is located in Sec. 31, T. 12 S., R. 4 E., S. B. M., one mile east of Julian.

Two parallel veins occur in schist, and have a general NW. strike, with a dip of 60° to 80° to the E. These veins have an average width of 12 in.

Development consists of two tunnels and a shaft 100 ft. deep. The lower tunnel is a crosscut driven N. 10° E. for 300 ft. About 200 ft. west of this tunnel, at a higher elevation, a tunnel has been driven N. 40° W. on a vein, a distance of 300 ft.; some stoping, both overhead and underhand. The ore mined is said to have an average value of $25 per ton.

The mine is equipped with a 5-stamp mill, flotation cells, pump for dewatering the mine, mine cars and track. It is leased to Atkins and Sidney Dodge.

Bibl.: State Mineralogist's Rept. XXI, p. 336.



Eagle Mine, showing 5-stamp mill and flotation cells.

Elvado and Aguajita Group is owned by A. M. Shook, 2137 Julian Ave., San Diego, Cal.; located in Sec. 12, T. 13 S., R. 4 E., S. B. M. This group consists of two claims and a mill site, patented. It is located two miles southeast of Banner.

Vein has free-milling gold quartz from 2 ft. to 10 ft. thick. Granite hanging and foot walls; NW.-SE. strike, with SW. dip. Entrance is by a tunnel 685 ft., with a 170-ft. drift to the south. The tunnel begins on the Aguajita and runs to the Elevado. Elevado was first worked from an old shaft high up on the ridge where a schist dike crops out on the surface, carrying considerable quartz. Later a crosscut tunnel was driven in from a point 600 ft. down the hill, intersecting the vein 635 ft. from the portal.

Elk and Landslide Claims are owned by R. D. and B. F. Moore, Julian. They are located in Sec. 3, T. 14 S., R. 3 E., S. B. M.

These claims are located on Kelley Creek, 12 miles south of Julian. Elk vein is 6 ft. wide and strikes NW. Quartz shows free gold associated with pyrite and arsenopyrite. Landslide vein has a width of 12 in. to 2 ft. and has an east and west strike. Both veins are in granite. Workings consist of a few prospect holes along the outcrops.

Frances Group is owned by Randcliff Heineman et al, San Diego. It is located in Sec. 9, T. 15 S., R. 5 E., S. B. M.

This group comprises 6 claims, the Frances, Ruth, Anna, Kitty, Nellie and Nora, on the west slope of the Laguna Mountains. On the property are several parallel veins in schist with a NW. strike and SW. dip. They have a width of 8 ft. to 10 ft., with prominent outcrops.

Development consists of a number of short tunnels and prospect holes on the ridge west of Noble Canyon.

Free Coinage is owned by Chas. Quale et al, Spreckles Bldg., San Diego, Cal. It comprises 2 claims situated in Sec. 12 and 13, T. 15 S., R. 4 E., S. B. M.

The vein occurs in granite; strike N. 30° W., dip 75° NE. Width of vein is 12 to 18 in. The main tunnel of 200 ft. connects with bottom of a shaft 100 ft. below the surface. There are two small open-cuts.

Bibl.: State Mineralogist's Rept. XXI, pp. 336-337.

Gardiner Mine (Gem). It comprises 3 patented claims situated in the Julian Mining District, in Sec. 4, T. 13 S., R. 4 E., S. B. M., 1½ miles east of Julian; owners, Frank Lane and Fred Jacobs, Julian, Cal.

The Gardiner vein occurs in Julian schist and is parallel to the Helvetia vein. The vein strikes NW. and SE.; dips 70° NE.; width varies from 6 in. to 2 ft. The vein quartz shows gold, associated with arsenopyrite and pyrite.

About 200 ft. in elevation below the old Banner grade road, the Waterman tunnel is driven as a cross-cut southwest 892 ft. to intersect the Gardiner and Helvetia veins. At an elevation of 3400 ft. and 200 ft. above the Waterman tunnel, a cross-cut tunnel is being driven southwest to intersect the Gardiner vein. The present length of tunnel is 300 ft., with 60 ft. to go to cut the vein.

Equipment consists of Gardner-Denver compressor, jackhammers and cars. Two men are employed.

Gold Cross No. 1 is owned by R. G. Melrose et al, Banner, Cal. It is located in Sec. 10, T. 13 S., R. 4 E., S. B. M.

This claim formerly was worked by Governor Waterman and is on the Cincinnati Belle vein. It has a gold-bearing vein of quarts 12 to 18 in. wide in schist. Workings consist of an 800-ft. tunnel and 3 shafts 90, 70 and 35 ft. deep. Idle.

Golden Chariot Group is owned by Mrs. Adelaide Elliott, 386 Parnassus St., San Francisco. It is located in Sec. 14, T. 13 S., R. 4 E., S. B. M. This property consists of 2 claims, the Golden Chariot and Chariot North.

The vein occurs in a contact of mica schist and gneissoid granite, the former being the foot-wall and the granite being the hanging-wall. The vein varies from 12 in. to 2 ft. in width; strike N. 20° W. and dips 65° NE. It is faulted on the east by a series of step faults. The gold ore occurs in lenses of quartz which is free-milling. Ore contains some pyrite and tellurium.

Development consists of 3 shafts sunk on vein: No. 1 shaft, 200 ft. deep; No. 2, 200 ft.; and No. 3, 350 ft.

All equipment has been removed from the property. Idle.

Bibl.: State Mineralogist's Reports VI, p. 86; IX, p. 147; XIII, p. 337; XIV, p. 658; XX, p. 372; XXI, pp. 337-339.

Golden Ella Mines No. 1 and 2 are owned by Max J. Demo et al, Julian, Cal., and are located in Sec. 14, T. 13 S., R. 4 E., S. B. M.

Workings consist of shaft sunk on vein to a depth of 130 ft. on Golden Ella No. 1 and 10 ft. of location work on Golden Ella No. 2. An 8-in. vein of gold-bearing quartz has been developed showing good values; strike N. 10° E.; dip 40° S. This vein is an extension of the vein occurring on the Chariot Mine to the south. The property is under lease to Walter F. Young, San Diego.

Equipment consists of headframe; 6-h.p. hoist; and portable compressor. One man is employed.

Gold King and Gold Queen Mines are owned by O. F. Heckelman, La Jolla, Cal. The property is located on a patented homestead in the SE.¼ of SE.¼ of Sec. 15, T. 13 S., R. 4 E., S. B. M.

On the Gold King Mine there is a shaft 134 ft. deep, with a drift 100 ft. The quartz vein is two feet wide in mica schist. Strike of vein is N. 30° W., dip 50° NE. The ore is free-milling.

On the Gold Queen vein, a shaft has been sunk to a depth of 200 ft., with a drift 400-ft. on the vein. Vein is 2 ft. wide; strikes N. 30° W., dips 80° NE. Idle.

Gold Reef Group is owned by W. W. Crosby, Descanso, Cal., and located in Sec. 14 and 23, T. 13 S., R. 4 E., S. B. M.

There is a 5-ft. vein of quartz showing gold values. The vein system on this claim is about the same as that on the Golden Chariot. Workings consist of a 30-ft. shaft, an open-cut 70 ft. long and 12 ft. deep and an inclined shaft 30 ft. deep. Idle.

Gold Dollar No. 1 and No. 4 are owned by Ignatz Rottman, 985 National Ave., Chula Vista, Cal. The property is located in the Pine Valley District.

A vein of mineralized schist shows gold values. Workings on Gold Dollar No. 4 consist of a 100-ft. shaft with headframe and hoist and a 25-ft. shaft with collar set and windlass. Idle.

Good Hope Group is owned by J. W. Swan, Julian, Cal., and located in Sec. 15, T. 13 S., R. 4 E., S. B. M. This group consists of 10 claims, Good Hope No. 1 to No. 8, inclusive, Blue Bell, and Viking, 4½ miles southeast of Julian.

Good Hope No. 5 has an opencut and tunnel 50 ft. long. All other claims have only shallow cuts 2 ft. and 3 ft. deep. No. 5 has a 4-ft. vein of quartz between walls of granite. Idle.

Granite Mountain Mine is owned by Gus Redman, Julian, Cal. It is located in Sec. 15, 16, 21 and 22, T. 13 S., R. 5 E., S. B. M.

This is a group of 7 claims about 10 miles southeast of Julian. The formation is schist, with gold values in quartz veins. The principal workings are on a vein which has a northerly strike and a westerly

dip. Width of vein is 6 in. to 2 ft. On this vein is a 60-ft. tunnel. Near the top of the ridge is a quartz vein about 8 ft. wide on which a tunnel has been driven north for 200 ft. This vein has a NW. strike and a NE. dip. Another vein 10 ft. wide runs about 200 ft. south of the mill, striking NW., with a W. dip. Idle.

Bibl.: State Mineralogist's Reports XIV, p. 660; XXI, p. 339.

Green Money Mine is owned by Clytie Bowles, 1439 Essex St., San Diego, Cal. It is located in Sec. 2, T. 13 S., R. 4 E., S. B. M.

This is a 1½-ft. vein of gold-bearing quartz with granite walls. A crosscut tunnel of 75 ft. to vein, with drifts north 210 ft. and south 70 ft. on the vein. At the north end of the claim are two tunnels, 150 ft. and 50 ft. Idle.

Group Mining Claims. This property is owned by Ben Record, Pine Valley, Cal., and is located in Sec. 13, T. 15 S., R. 4 E., S. B. M. Claims in this group are Barbara, Mesa and Sela.

The vein quartz carries values in gold and silver. Development consists of an 85-ft. shaft, 85-ft. tunnel and 2 drifts, 35 ft. and 15 ft. Idle.

E. A. Harper Ranch Mine is owned by E. A. Harper, Julian, Cal. Its location is described as Lot H of partition of Rancho Cuyamaca. This is a patented claim.

The vein of quartz has a width of 12 in. Workings consist of a 165-ft. shaft and 55 ft. of drifting. Equipment consists of 12 h.p. gas engine hoist. Idle.

High Peak Group is owned by L. A. Smith and the Marks Sisters, 2441 Pamo Ave., San Diego, Cal. It is located in Sec. 31 and 32, T. 12 S., R. 4 E., S. B. M., in Julian Mining District. This is a group of four claims, High Peak, Roselyn, South High Peak and Roosevelt.

There are two parallel quartz veins in schist. Width of veins is from 1½ to 4 ft. The veins strike N. 30° W.

Development consists of a tunnel running 375 ft. westerly to connect with the north tunnel of the Eagle Mine, at which point there is a shaft 330 ft. deep and about 1300 ft. of drifts on tunnel level.

Bibl.: State Mineralogists's Reports X, p. 542; XII, p. 241; XIII, p. 339; XIV, pp. 656-659; XXI, pp. 339-340.

Kentucky S. Group is owned by R. G. Melrose and Fred N. Farmer, Banner, Cal. It is located northwest of Banner in Sec. 3, T. 13 S., R. 4 E., S. B. M. This group consists of the Kentucky, Cincinnati, Wedge, Contact, Gold Leaf and South Kentucky claims.

On the Kentucky S. are two veins 2 ft. to 4 ft. in width, NW. strike, with a SW. dip; free-milling ore. The hanging and foot-walls are schist. Workings consist of a tunnel 1740 ft. long and 2 shafts, one 200 ft. and the other 50 ft. deep.

The Cincinnati Belle is an adjoining claim. A 1000-ft. tunnel begins on Contact Claim and crosses the Hidden Treasure, Kentucky S. and Cincinnati Belle. Under lease and bond to Frank Herron, Security Bldg., Pasadena, Cal. Three men are employed.

Bibl.: State Mineralogist's Reports, X, p. 542; XI, p. 380; XII, p. 241; XIII, p. 340; XXI, pp. 340-341.

Last Chance Mine. The ownership is in litigation. It is located in Sec. 4, T. 14 S., R. 3 E., S. B. M. The property comprises 5 claims in the Boulder Creek District, on the west slope of the Cuyamaca range of mountains, 12 miles southwest of Julian.

The vein strikes N. 20° W. and is vertical. It probably is a fault fissure in the granite. Width of vein is one to 4 ft. A two-compartment shaft has been sunk to 110-ft. level, with ore occurring in the bottom. Ore shoot north of the shaft has been underhand stoped to a depth of 25 ft. At the 40-ft. level, a drift has been run to the south of the hanging-wall side of vein, for a distance of 70 ft. At the 100-ft. level, a drift has been run on the vein 20 ft. Vein-filling carries free gold with pyrite and marcasite. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 341.

Long Valley Mine, comprising 4 claims, is in Sec. 25, T. 16 S., R. 4 E., about 6 miles east of Descanso; owner, Walter R. Horr, Campo, Calif.

This discovery was made in February, 1939, by Horr, who traced placer gold in the wash for about 3½ miles. He located the claims as both placer and lode. It is said that placer values occur in the shallow washes over an area three miles square. The fine placer gold apparently occurs in a decomposed granitic rock. No estimate of the extent or average values of the deposits could be made at the time of visit.

The topography is that of a gently rolling plateau and the surface is covered with brush. The country rock is granite and mica schist. In these rocks there is a series of northwest-southeast veins; also a series of subordinate east-west fractures. Due to the brush and the fact that but little work had been done at the time, it was impossible to get much information on these veins. What appears to be the principal one had been exposed by a few superficial open cuts for a length of about 350 ft. It varies in width from a few inches to a maximum of 4 ft. The glassy, vitreous quartz filling pans some free gold.

Altogether, there were 8 men prospecting in the area.

Madden Group of Mines. It comprises 5 claims situated in Julian Mining District, in Sec. 3 and 4, T. 13 S., R. 4 E., S. B. M., one mile northwest of Banner; elevation 3500 ft. Owner is C. W. Curry, Julian, Cal.

Two parallel veins occur in schist, strike NW. and dip 70° SW.; widths 12 in. to 2 ft.

Development is confined to the Madden and Antelope claims. On the Antelope Claim there is a crosscut tunnel driven southwest 550 ft., with 300 ft. of drifts on the vein. On Madden Claim, the workings consist of a shaft on the vein to a depth of 100 ft., with drift north 60 ft. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 341.

Margaret Mine is owned by J. S. and Marguerite Burns, Guatay, Cal., and is located in Sec. 31, T. 14 S., R. 5 E., S. B. M. This location comprises two claims in the Deer Park Mining District.

Four parallel veins varying in width from 12 in. to 2 ft. have a northerly strike dipping 50° E. There is a shaft 80 ft. deep on Marguerite Claim. Vein quartz shows free gold and pyrite. Idle.

Bibl.: State Mineralogist's Rept. XXI, pp. 341-342.

Melba Group is owned by Dr. C. J. Keeton et al, 530 Commonwealth Bldg., San Diego. It is located in Sec. 5, T. 15 S., R. 5 E., S. B. M. This is a group of 3 patented claims, Rosa, Grace and Elizabeth.

Gold occurs in veins of quartz, 2 to 3 ft. wide. Workings on the Rosa Claim consist of three tunnels, 70, 180 and 300 ft. and one shaft 90 ft. deep. There is an 80-ft. tunnel on the Grace Claim. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 342.

Montana Group is owned by Walton Bros., Thirteenth and F St., San Diego, Cal. It is located in Sec. 1, T. 14 S., R. 4 E., S. B. M., and consists of 8 claims located on the north slope of the Laguna Mountains.

On Montana No. 1 there is an inclined shaft 260 ft., dipping to the east. A porphyry dike in granite carries gold values. Equipment consists of head-frame, hoist, blower and compressor.

On the Oriflamme South No. 2 there is a tunnel 178 ft. driven east, crosscutting a 56-ft. porphyry dike at 126 ft. There are three men working.

Montezuma Group is owned by R. J. Stauch, 8805 Fifth Ave., Inglewood, Cal. It is located in Sec. 10, T. 11 S., R. 4 E., S. B. M., 6 miles southeast of Warner Springs on the slope of San Ysidro Mountain and consists of 4 claims.

The formations are mica-schist, gneiss, quartzite and limestone and are adjacent to a large granite area. The veins strike N. 65° E., dip 70° NW. and are well-defined fissures that cut the rocks both on strike and dip. Considerable development work has been done on the property. Idle.

Bibl.: State Mineralogist's Reports XV, p. 648; XXI, pp. 342-343.

Noble Group. This group is located on the west escarpment of the Laguna Mountains, about 5 miles north of Pine Valley. A good road maintained by the U. S. Forest Service extends from the property to Highway No. 80. The claims are located in Sec. 7 and 17, T. 15 S., R. 5 E., S. B. M. The holdings consist of 9 claims, viz.: Oxide, Telluride, Millsite, Bay View, Treasury, Eureka No. 1 and No. 2, Spring No. 1 and No. 2. The property originally was discovered by John Noble. Owners are estates of John and Tom Noble, San Diego, Cal.; under lease to Carl Reilly, San Diego, Cal.

Extending in a northwest direction are a series of parallel veins in schist, the mineralized portion being a mile wide. Most of the development work has been done on the Eureka and Treasury vein.

Bay View Claim: The topmost of the claims on the escarpment of the mountain has a vein 3 ft. wide. The workings consist of an adit 50 ft. on the vein and an opencut; vein strikes NW., dip E.

Eureka Claim: The workings on this claim consist of 2 tunnels (35 and 150 ft.), a shaft 100 ft. deep, with drifts on the 50- and 100-ft. levels. A crosscut tunnel is now being run to intersect the vein on the Treasury Claim. Some high-grade ore has been developed on this claim.

Treasury Claim: A tunnel has been extended 330 ft. southeast into the mountain on the vein which is 18 to 24 in. in width. The vein is on the contact of schist and granite. Near the face of the tunnel a raise has been made to the surface. Work is now in progress to crosscut this vein at depth.

Spring Claim: The development work on this claim consists of a 200-ft. vertical shaft, with drifts on the 60-, 80-, 100-, 150-, and 200-ft. levels. The shaft is full of water. A 25-h.p. hoist with gallows frame is housed in a galvanized iron shed.

Telluride Claim: A crosscut tunnel has been extended to the east to cut a low-grade dike outcropping on the hill. This dike is about 150 ft. in width and extends a considerable distance off the property to the south. On this claim is the camp.

Oxide Claim: The vein on this claim is 8 to 10 ft. wide, near the contact of the schist with the granite. It is developed by a tunnel which follows the vein; workings caved.

The milling equipment which is located on the Mill Site Claim, consists of grizzly, ore bin, Blake crusher, ore feeder, 5-stamp mill, 7-ft. Lane mill, amalgamating plates and 2 Frue vanners. Mill is driven by a 22-h.p. Foos gas engine. It was driven formerly by water power. The water supply is from springs at the head of Noble Canyon which water is conveyed by a 3500-ft. wooden flume. The flume is connected to Knight 40-in. waterwheel by 200 ft. of 8-in. pipe.

Bibl.: State Mineralogist's Reports IX, p. 141; X, p. 544; XI, p. 382; XII, p. 238; XIII, p. 342; XIV, pp. 663-664; XXI, pp. 344-345.

Owens Mine is owned by Howard Williams, 1626 Seventh St., San Diego. It is located in Sec. 31, T. 12 S., R. 4 E., S. B. M., in the Julian Mining District, one-half mile north of Julian. There is one claim, patented.

The vein of free-milling gold quartz is 6 in. to 6 ft. wide, almost perpendicular, with a NW.-SE. strike. The hanging and foot walls are schist. At the time of production the main shaft was 400 ft. deep, with 800 ft. of drifts. The mine then was equipped with boilers, hoist, pumps and stamp mill. At present it is idle.

Bibl.: State Mineralogist's Report XXI, pp. 345-346.

Parsons Mine is owned by Everett Parsons, El Cajon, Cal. It is located in Sec. 23, T. 16 S., R. 1 W., S. B. M., on patented land.

Gold and a little silver occur in a vein of white quartz, with hematite, 2 in. to 2 ft. wide. Workings consist of a vertical shaft, with drifts north and east. The east drift connects with an air shaft to the surface.

The mine is equipped with a 2-stamp mill with amalgamation plates. Custom milling is done at this mill for other properties.

Pioneer Lode Mine is owned by C. S. Young, 2417 South Hope St., Los Angeles. It is located in Sec. 9 and 10, T. 14 S., R. 3 E., S. B. M., 14½ miles southwest of Julian on Boulder Creek Road.

There is a 12-in. vein of gold-bearing quartz. Workings consist of 100-ft. tunnel with 200 ft. of drifts; one stope from tunnel 175 ft. to surface and 2 other stopes 63 and 50 ft.; shaft 50 ft. Idle.

Poor Man's Group is owned by Quayle Bros., et al, Spreckles Bldg., San Diego. It is located about 2 miles south of Banner in Sec. 11, T. 13 S., R. 4 E., S. B. M. This group consists of 6 claims: Poorman, Chariot No. 4, Chariot No. 5, Banner Gold, Homestake and Treasure Hill.

Gold values occur in a 3-ft. vein of free-milling quartz. Hanging-wall is granite; foot-wall schist. Gold averages 976 fine. Poorman Claim is developed by a shaft about 100 ft. deep and about 190 ft. of surface trenching 4 ft. deep. Workings on other claims of the group include a 300-ft. tunnel. Idle.

Pride of the West Mine. It is owned by Fred Sawday, Julian, Cal., and located in Sec. 36, T. 12 S., R. 3 E., S. B. M. This is a patented claim on the Sawday Ranch, 1½ miles west of Julian.

Gold occurs in a 12-in. to 3-ft. vein of quartz and schist, between granite walls; strike N. 15° W.; dip 65° E.

Development consists of crosscut tunnel driven east 340 ft. to vein with a drift south 165 ft. and north 90 ft. In 1937, 200 tons of ore was milled, reported to have had an average value of $80 per ton. The production is $14,000. Idle.

Ranchito Mine is owned by Cave Couts, Vista, Cal., and is located 2 miles south of Banner in Sec. 12, T. 13 S., R. 4 E., S. B. M., on a 160-acre patented homestead; under lease to William Martin, Hemet, Cal.

The mineralized zone consists of a belt of schist about 30 ft. wide, strike N. and S.; dip 58° NE. at the surface and straightens up to 70° at 150-ft. depth. The mineralized quartz vein follows along the foot-wall of the schist belt. Development consists of 2 shafts, one 250 ft. and the other 165 ft. The vein appears to be made up of a series of parallel quartz lenses which cut the strike of the schistose formation at an angle of 20°. The lenses terminate on reaching a fault striking east and west. These quartz lenses are one to 3 ft. in width and from 4 to 5 ft. apart.

Present development consists in sinking a vertical 2-compartment shaft 300 ft. north of old shaft in foot-wall granite. Shaft is 330 ft. deep. They are cutting a station on 330-ft. level; plan to crosscut east to vein.

Equipment consists of Gardner-Denver compressor, driven by 35-h.p. Hart-Parr diesel engine; 12 h.p. gas engine hoist.

The Elevado vein on the same property has a northerly strike and dips 45° W. Workings on this property consist of 160-ft. shaft and a crosscut tunnel driven 200 ft. to the vein. From the shaft, levels have been driven at 50 and 100-ft. intervals; stoped to the surface.

The property is equipped with a 5-stamp mill, hoist, gallows frame, track and mine cars. Five men are employed.

Bibl.: State Mineralogist's Rept. XXI, p. 346.

Five-stamp mill on the Ranchita Mine

Ready Relief-North Hubbard Mines are owned by North Hubbard Mining Co., L. V. Lloyd, president, 2533 S. Hill St., Los Angeles; Harry W. Phillips, secretary; under lease and bond to Moro Bay Copper Co., Ogden Chase, president, Salt Lake City, Utah. This group of 11 claims, located in Sec. 3, 10 and 11, T. 13 S., R. 4 E., S. B. M., 3 miles southeast of Julian, is one of much historic interest in the Julian District. The group comprises the Ready Relief, North Hubbard, South Hubbard, Carp, Raindrop, Belmont, Redman, Northwest Redman, Hidden Treasure, Fountain and Tom Paine claims.

The group has been one of the most productive in the district. The veins average 2 ft. in width. They strike NW.-SE. and dip NE. in the Ready Relief and SW. in the Redman. The hanging and footwalls are schist. Workings on the Ready Relief consist of a 200-ft. shaft and 4 tunnels of average 600-ft. length on the vein. On the Redman Mine there is a vertical shaft 114 ft. deep, on the 110-ft. level, drift N. 300 ft. On this level developed 2 ore shoots 45 ft. in length;

width of ore 8 in. to 2 ft. The shaft is being unwatered. Since the XXI Report of the State Mineralogist on the North Hubbard, the southeast drift has been extended to 300 ft. from crosscut with some stoping. Also, a winze has been sunk to a depth of 100 ft. in north drift.

Gold was discovered on the property in the summer of 1870 by Louis Redman, who had been grubstaked by D. D. Bailey, founder of Julian. By previous arrangement, Bailey filed on the adjoining claims. The property was owned by members of the Bailey family until 1932 when it was sold to the present owners.

For many years a 10-stamp mill was operated on Ready Relief claim by D. D. Bailey. Power for the mill was obtained by piping water from a large spring on the mountainside.

Redman Mine is under lease to D. S. Truelsen, Julian, Cal. Two men are employed.

Bibl.: State Mineralogist's Reports VI, pp. 87-88; VIII, pp. 513-514; IX, p. 147; X, p. 543; XI, pp. 378-380; XIII, p. 344; XIV, p. 657; XX, p. 373; XXI, pp. 346-347.

San Diego Mine is owned by Howard Williams, 1627 Seventh St., San Diego, Cal., and is located in Sec. 5, T. 13 S., R. 4 E., S. B. M.

On this claim there are 2 veins of free-milling gold quartz, with schist walls. The strike is NW.-SE. and the dip NE.; width of veins 4 ft. Workings consist of 3 tunnels, 100, 150 and 300 ft.; and 2 shafts, 40 and 50 ft. Idle.

Silver King Mine is owned by George Moyer, Julian, Cal., and located in Sec. 2 and 3, T. 14 S., R. 3 E., S. B. M., 14½ miles southwest of Julian on Boulder Creek Road.

A vein 5 ft. wide with a NW. strike and a dip 35° NE. occurs in a belt of mica schist 600 ft. wide. Workings consist of a crosscut tunnel 110 ft., with drifts of 35 and 40 ft. The quartz is mineralized with gold associated with galena and pyrite.

Bibl.: State Mineralogist's Rept. XXI, p. 348.

Summit and Summit Extension. This property is owned by More and Feiler, Julian, Cal., and is located in Sec. 11, T. 14 S., R. 3 E., S. B. M., 12½ miles southwest of Julian, on Boulder Creek Road.

An 18-in. vein of schist and quartz shows gold values. Workings consist of one tunnel 100 ft. and 2 shafts, one 45 ft. and the other 15 ft. in depth.

Tom Scott Mine is owned by C. W. Curry, Julian, Cal., and is located in Sec. 31, T. 12 S., R. 4 E., S. B. M. This is a patented claim one-fourth mile north of Julian.

Two parallel veins of quartz 18 in. wide are between schist walls. The strike is NW.-SE. and the dip NE. Workings consist of 225-ft. shaft and a 300-ft. tunnel. The shaft has been recently retimbered. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 349.

Van Wert Mine is owned by the Joseph Marks Estate, Julian, Cal., and is located in Sec. 31, T. 12 S., R. 4 E., S. B. M. This claim,

located one mile north of the Julian post office, was one of the first discovered in the Julian District.

The vein is 18 in. to 2 ft. wide, in mica schist, strikes NW. and dips NE. Workings consist of 2 crosscut tunnels, 200 ft. in length to vein, with a drift of about 150 ft. along the vein in the north tunnel; stoped to the surface. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 349.

Warlock Group is owned by Mattie Mining & Milling Co., E. H. Messatt, president and manager, San Diego, Cal. This group consists of Belrock, Warlock, Neptune and Ruby claims. The company has under lease the Shamrock and Padlock. The claims are located in Sec. 4, T. 13 S., R. 4 E., S. B. M., on the escarpment of the hill leading from Julian to Banner.

Development: At an elevation of 3200 ft., a crosscut tunnel has been driven S. 20° W., 1660 ft., starting on the Warlock Claim, cutting the 5 veins occurring on the Warlock, Neptune and Ruby claims. At 1330 ft., cut the Shamrock vein which strikes N. 60° W.; dip 40° S.; width 12 in. to 4 ft.; a drift southeast 200 ft. and northwest 100 ft. on the vein. In the southeast drift raise put up 60 ft. on the vein. Vein quartz shows free gold associated with arsenopyrite.

Equipment consists of a 2-drill compressor, driven by a gas engine; concrete storage tank, capacity 39,000 gal.; 2800 ft.of 3-in. pipe line from pumping plant on creek to storage tank; mill building with no machinery installed.

Four men are employed.

Washington Mine is owned by W. C. Barker, et al, 610 San Diego Trust & Savings Bank, San Diego, and is located in Sec. 31, T. 12 S., R. 4 E., S. B. M.

As a point of historic interest, the first important discovery of gold in San Diego County was made on this property February 22, 1870. It accounted for the rush of miners to that region and eventual development of the Julian District. Gold occurs in a quartz vein having a NW.-SE. strike and a NE. dip. The hanging and foot walls are schist. The vein is 18 in. wide. The mine is developed by a 100-ft. tunnel and a 100-ft. shaft. From bottom of the shaft a 300-ft. drift has been driven on the vein. Idle.

Whaley Mine is owned by John Kunis, De Luz, Cal., and operated under lease by Whaley, Harrison, Bisbee, et al., Fallbrook, Cal. It is located in the N. ½ of SE. ¼ of Sec. 28, T. 8 S., R. 4 W., S. B. M.

This is a patented property having a vein of free-milling gold quartz 2 to 7 ft. wide. Porphyry appears south and parallel to the fissure, with a rhyolite dike on the north. The fissure seems to be faulted on the southeast extremity.

The property is equipped with a 20-ton ball mill, driven by 10-h.p. engine; ore bin; concentrating table. Two men are employed.

Winatoma Mine is owned by L. B. Spaulding, Ramona, Cal., and is located in the S. ½ of Sec. 16, T. 16 S., R. 6 E., S. B. M.

There is a 12-in. vein of gold-bearing quartz. Property is developed by a 45-ft. shaft and a 10-ft. open cut.

IRON

Deposits of iron ore occur near Campo, Flinn Springs and Lakeside. The ore encountered in the various localities consists of magnetite and hematite.

Iron Master Group of Claims is owned by Dr. M. C. Harding, Electric Bldg., San Diego, and located about 6 miles east of Lakeside, in T. 15 S., R. 1 E., S. B. M. There are 8 claims in this group.

The ore occurs as magnetite in the granite. Extent of the deposit is not fully explored. Two feet of ore are exposed in one prospect hole of shallow depth. Idle.

Bibl.: State Mineralogist's Report XXI, p. 350.

Lakeview Group of Claims is owned by Dr. M. C. Harding, Electric Bldg., San Diego, and is located in T. 15 S., R. 1 E., S. B. M., on the south slope of El Cajon Mountain, 3 miles northeast of Lakeside.

The ore occurs as hematite and magnetite. Analysis of ore is stated to show 70% iron, with low phosphorous and sulphur content. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 350.

Companion No. 1 Mine is owned by Frank Beal, Campo, Cal., and is located 2½ miles southwest of Campo, one-quarter of a mile north of San Diego & Eastern Arizona Railroad, in Sec. 22, T. 18 S., R. 4 E., S. B. M.

On this property iron occurs in granite. Development work consists of 2 shafts, one a vertical shaft 40 ft. deep, and the other inclined at about 50° to a depth of 30 ft. A large number of pieces of magnetite have been extracted. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 350.

LEAD

The ores of lead have been found in various parts of the county, generally associated with the gold veins at the Descanso Mine and the mines in the Deer Park District of the Laguna Mountains. The chief occurrence is at Valley Center.

Bradbury Property is owned by W. M. Bradbury, 116 South Broadway, Escondido, Cal. This property comprises 2 claims, known as *Surprise Mine* and *Surprise Mine No. 2,* located in the NW. ¼ of Sec. 1, T. 11 S., R. 2 W., S. B. M., 2½ miles northwest of Valley Center.

The ore is galena and sphalerite in a quartz vein 2 ft. in width. Workings consist of 2 shafts, 20 and 30 ft. deep. Idle.

MANGANESE

At several localities in the county are surface indications of manganese, generally in the form of oxide; also, rhodonite, the silicate, has been found in two locations. It is questionable whether these deposits will become commercial on account of the high silica content. Beautiful specimens of rhodonite are found in the county, notably in Anza State Park in the northeastern part of the county near the Riverside County line. These specimens are sold to local gem cutters.

Jacumba Manganese Group. This group is located one mile northwest of Jacumba, in Sec. 5 and 6, T. 18 S., R. 8 E., S. B. M., and is owned by Dr. M. C. Harding, 861 Sixth Ave., San Diego.

Occurring on this property is a 4-ft. vein of a low-grade manganiferous iron, with a high silica content. Two shallow test pits have been put down, revealing the ore in place.

Bibl.: State Mineralogist's Rept. XXI, p. 350.

Sunrise Mine is owned by Calvin W. Garrison, 3659 Cherokee St., San Diego, and located in Sec. 10, T. 13 S., R. 5 E., S. B. M., about 9 miles east and north of Banner.

A 5-ft. vein of manganese oxide occurs on this property, carrying gold values. The property has been developed by 2 tunnels, one 8 ft. in length, the other 50 ft. Idle.

MOLYBDENUM

Extending northwest from the Mexican border, one mile east of Campo to San Pasqual, there is a belt of aplite granite that is impregnated with molybdenite. Along this belt there have been found about twenty outcrops of the ore which occurs disseminated as flakes and in small masses. Except at Campo and 6 miles east of Ramona, no exploitations have been made of the various exposures.

Bour Molybdenum Mine is owned by Mrs. E. M. Bour, 2218 Harrison St., San Diego, and located in Sec. 11, T. 13 S., R. 1 W., S. B. M. The mine is on a patented homestead of 40 acres.

The workings on this property consist of a crosscut tunnel 165 ft. long run to intersect the vein, with several crosscuts and an extensive open-cut on the vein. The mineralized zone is about 30 to 200 ft. in width by 1500 ft. in length. The ore occurs in flakes and small masses in aplite dikes. The ore milled from property is reported to have averaged 0.5% MoS_2.

Bibl.: State Mineralogist's Rept. XXI, p. 351.

Campo Molybdenum Mines (Midway) are owned by A. G. Foster and Wm. Davis, 6137 El Cajon Ave., San Diego, Cal. This property consists of 3 mining claims, Mother Lode, Midway and Eldorado, on a patented homestead in the NW. $\frac{3}{4}$ of Sec. 16, T. 18 S., R. 5 E., S. B. M.

Exposed in a railroad embankment is an aplite dike 40 ft. across at its summit and broadening to 250 ft. at its base that contains disseminated flakes of molybdenite and iron pyrite. The entire dike, where exposed, is impregnated with molybdenite. A 20-ton concentration and flotation plant has been installed on the property. Water is available from Campo Creek on the property. Six men are employed.

Bibl.: State Mineralogist's Rept. XXI, p. 351.

Dillbeck Molybdenum Deposit is owned by J. L. Dillbeck, Campo, Cal., and under lease to Campo Molybdenum Co.; T. W. Buckel, president, Holtville, Cal.; E. C. Leistikow, superintendent. This property is located in Sec. 16, T. 18 S., R. 5 E., S. B. M., one mile west of Campo and adjoins the Campo Mine on the east.

The formation is a wide dike of aplite granite with a NW. strike. The molybdenite occurs with iron pyrite disseminated in the granite over a wide area. The property has been developed by a large glory hole from which 200 tons of molybdenite ore has been extracted and placed on the dump ready for milling.

The property is equipped with gas engine driven compressor. Operations are being conducted with the view of extracting ore from the glory hole. They plan to install a concentrating plant.

Fernbrook Mine is owned by Mrs. Charlotte Ronan, 3402 Olive St., San Diego, and located 500 ft. south of Fernbrook Store and resort. This is a patented claim.

The deposit, about 200 ft. wide, is aplite granite containing molybdenum, associated with pyrite. Workings consist of a glory hole about 50 ft. in circumference and 12 ft. deep. Idle.

Judson Molybdenite. This property is owned by Chas. Judson, San Pasqual, Cal., and located in Sec. 1 and 12, T. 13 S., R. 1 W., S. B. M. It is patented.

The ore occurs in aplite granite 50 to 100 ft. in width, mineralized with molybdenite. There was a small production from the property. Idle.

NICKEL

Only one deposit of nickel occurs in the county. This location was originally opened up as a copper mine but at depth the ore changed to a pyrrhotite carrying from 4 to 5% nickel.

Friday Mine is owned by Friday Copper Mining Co., San Diego, Cal.; lessee, Sheldon P. Fay, Los Angeles. This property consists of one claim located in the SW. $\frac{1}{4}$ of Sec. 15, T. 13 S., R. 4 E., S. B. M.

The surface indications of iron gossan strike east over a width varying from 25 to 50 ft. and extend west to Sec. 16. In the upper workings of the mine copper sulphides and carbonates with more or less nickel are found. At depth the ore changes to pyrrhotite.

The property has been developed by a one-compartment vertical shaft, recently timbered, to a depth of 130 ft. From the 130-ft. level, the shaft is sunk on an incline of 70° for a distance of 45 ft. On the 130-ft. level, an ore-body containing phrrhotite 60 ft. long and 20 ft. wide was developed. This body lies near the contact of gabbro and schist and in some cases, is encased in gabbro. At the bottom of the 45-ft incline, the ore-body is 16 ft. long by 10 ft. wide. Several analyses of the ore have been made by different assayers showing the pyrrhotite to average between 2 and 5% nickel.

The present lessee has leased an adjoining mineralized area and intends to do some diamond drilling to prospect the surrounding ground.

Bibl.: State Mineralogist's Reports XIV, pp. 666-667; XVII, pp. 380-381; XXI, pp. 352-353; U. S. G. S. Bull. 640-D.

TIN

In the workings of the gem deposits in the northern part of the county, cassiterite is encountered as a brown or black crystal. Cas-

siterite is also found in the black sands in the gulches on the east slope of the Laguna Mountains. No commercial deposits have as yet been discovered.

TUNGSTEN

In the area north of Chihuahua Valley, extending into Riverside County in the vicinity of Beauty Mountain, the existence of scheelite has been known for some time. As a result of publicity given this region after the area had been inspected under a WPA project, interest was manifested by prospectors, who have to date located fifty or more claims therein, being guided to some extent in the selection of the mineralized ground by the flourescence of the scheelite under the influence of the violet-ray lamp.

The area in San Diego County embraces the north sections of T. 9 S., R. 3 E., S. B. M., and extends north into Riverside County. The yellowish crystals occur disseminated in a matrix of siliceous iron-stained mineral.

Four small concentrating plants have been installed in the region and are producing scheelite concentrates reported to run 65% WO_3 content.

Beauty Mountain Tungsten Mines are owned by Marie B. Teuscher, Claremont, Cal.; W. A. Teuscher, superintendent. The property comprises 3 claims situated on the boundary line between San Diego and Riverside counties. The claims are located in Sec. 1, T. 9 S., R. 3 E., S. B. M.

They have been developed by small prospect shafts, the principal work being on Scheelite No. 2. They plan to install a 20-ton concentration plant. Two men are employed.

Easy Group of Tungsten Mines is owned by Lloyd Mitchell et al, Aguanga, Cal. It comprises 4 claims located in Sec. 5, T. 9 S., R. 3 E., S. B. M.

Improvements consist of shallow shafts on each of the properties, including a small concentrating plant. Water supply for the mill is piped 5000 ft. During the past year this property has been producing concentrates that are said to average 65% tungsten oxide.

NONMETALLIC MINERALS

San Diego County has a wide variety of commercial nonmetallic minerals and a considerable tonnage is shipped by trucks and railroads to the manufacturing centers of other parts of the state.

Nineteen commercial minerals are produced in the county, among which are granite (silver-grey and black), marble and limestone, clays, feldspar (orthoclase), silica, fuller's earth, salt, mineral waters, and gems. The county ranks fourth in the world in the variety and production of semi-precious gems.

CLAY

Three types of clay having commercial value are found in San Diego County. Extensive deposits of shale and clay suitable for the manufacture of brick and tile occur, paralleling the coastal terrain from Carlsbad south to Ladrillo. At the summit of El Cajon Moun-

tain, 22 miles east of San Diego, are two deposits of kaolin suitable for ceramics. Owing to difficulties of transportation involved in working these deposits, development of them has been retarded. A deposit of fire clay east of Cardiff has been exploited. For a number of years local brick and tile companies have operated extensively in Rose Canyon, where the deposit extends for a distance of 3 miles and is sufficient to supply demands for years to come.

Dorothy and Pearl Claims. These 2 patented claims are located in Sec. 4, T. 13 S., R. 3 W., S. B. M., 5 miles northeast of Cardiff.

The clay is white, semi-plastic, fire clay. Its principal value is its refractory qualities. A number of test pits and benches have been dug that expose the deposit over a considerable area. The exposed bank is 10 to 12 ft. high. Material is shipped to plants in Los Angeles and San Diego.

El Cajon Kaolin Deposit. This deposit is located on El Cajon Mountain, 4½ miles northeast of Lakeside. Holdings consist of 2 claims.

The clay is mixed with grit but is free from iron. It is exposed at various points on the claims. The deposit has been developed by a number of tunnels and shafts. The main tunnel is 75 ft. long and 50 ft. below the surface. The stratum has a thickness of 50 ft. Shipments formerly were made from the deposit. No work has been done in recent years.

Bibl.: State Mineralogist's Rept. XXI, p. 354.

Merrick Kaolin Deposit is located in the NW. ¼ of Sec. 36, T. 14 S., R. 1 E., S. B. M., at an elevation of 2700 ft., 4½ miles northeast of Lakeside. It is patented. The owner is Michael Merrick, Barstow, Cal.

This is a deposit of pure white kaolin on which some test pits have been sunk. Owing to inaccessibility of the region no shipments have been made.

Morton Clay Deposit is 3 miles east of Farr Siding on the Santa Fe Railroad, one mile south of Carlsbad. It consists of 30 acres. The owner is G. H. Morton, Elsinore, Cal.

The clay is a white, plastic, vitrifying clay, slightly iron-stained. Not much work has been done on the deposit to determine its extent.

Bibl.: State Mineralogist's Rept. XXI, p. 355.

Pacific Clay Products Co., Wm. Lacy, president; offices, Chamber of Commerce Bldg., Los Angeles, has a deposit located 3 miles east of Farr Siding, on the Santa Fe Railroad. The property, comprising 25 acres, is a part of the old Kelley Ranch.

The clay beds are exposed on a low hill. The upper 10 to 15 ft. is a white, plastic, vitrifying clay, slightly iron-stained. It is underlaid by a bed of yellow and blue plastic clay. The beds have been prospected by a number of test pits. A bench has been established for mining the upper bed of white clay separate from the yellow and blue. The exposed bank of white clay is 275 ft. long.

Bibl.: State Mineralogist's Rept. XXI, p. 356.

Union Brick Co., J. W. Rice, secretary-president, operates two brick-making plants in Rose Canyon, in the northwestern part of the city of San Diego. The company makes a dry-pressed brick and a sand-moulded brick in the upper plant. The plant is operated only during the summer months.

The material is obtained from the bluffs on the west side of the canyon where there are deposits of thin-bedded, hard clay and shale, yellowish in color. These deposits occur in banks 50 to 75 ft. in height. Underlying these banks is a bed of plastic clay, blue-gray in color.

The plant is equipped with two brick presses. The bricks are burned in open air oil-fired kilns.

Bibl.: State Mineralogist's Rept. XXI, p. 357.

Vitrified Products Corp., C. F. Harnish, president; Sadie S. Wilson, secretary; E. M. Denton, manager; office, 4570 Pacific Blvd., San Diego, owns clay deposits comprising 16.6 acres in Lot 18, Rancho Las Encinitas, 5 miles northeast of Cardiff.

Beds of fire clay 10 to 12 ft. thick have been exposed by two open-cuts on the east and west sides of a small hill. They are nearly horizontal. The clay is moderately hard, and varies in color from buff to blue-gray and light purple. Operations of the company are intermittent.

The Linda Vista deposits formerly owned by the company have been abandoned on account of the material being too low grade for its use.

Bibl.: State Mineralogist's Rept. XXI, p. 357.

FELDSPAR

San Diego County contains large deposits of massive, high-grade feldspar which is unusually free from black mica and other deleterious iron-bearing minerals. San Diego, Riverside and Kern counties furnish practically all the feldspar produced in California. The principal deposits that have been developed are in the vicinity of Campo, Dos Cabezas, Lakeside and Jacumba. The largest feldspar deposit in the state is located in the Campo District and has been operated on an extensive scale for the past fifteen years by the *Standard Sanitary Manufacturing Co.*, Richmond, Cal.

Buckthorn Mine is leased to the *Chamberlain Co.*, 2550 East Ninth St., Los Angeles, and located in Sec. 36, T. 16 S., R. 6 E., S. B. M.

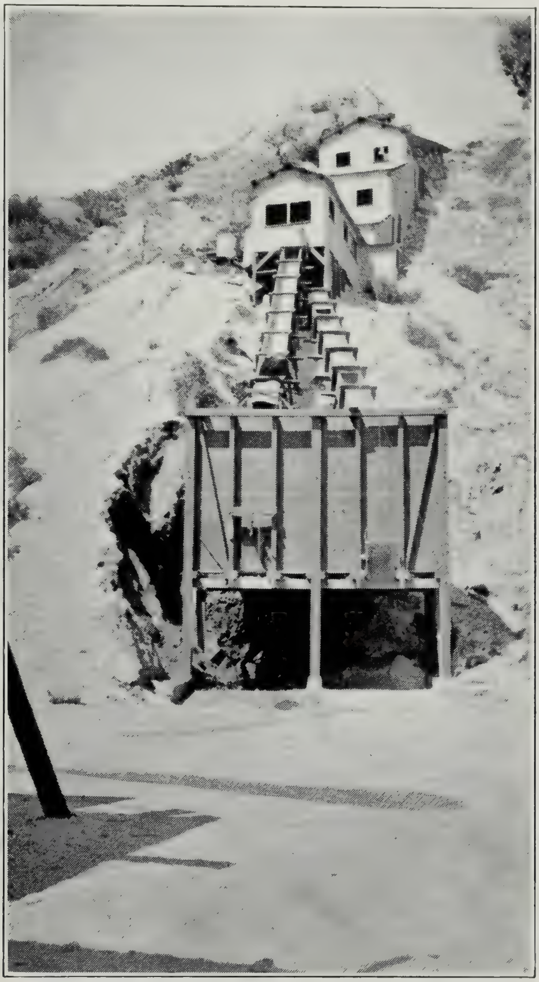
This is a large deposit of commercial feldspar and silica occurring in granite. The property is developed by one tunnel 13 ft. long bearing northeast into the hill; two other tunnels, 75 and 65 ft., respectively; and a shaft 50 ft. deep. The width of this vein is 100 ft. Shipments are being made to Los Angeles. Four men are working.

Campo Feldspar Deposit is owned by *Standard Sanitary Manufacturing Co.*, San Francisco, and is located on the hill on the north side of Hauser Canyon about 5 miles north of Campo.

This is the largest deposit of feldspar in the county. It consists of a massive outcrop of feldspar and silica, striking NE. and is traceable on the surface for about 1600 ft. Its width is 300 to 500 ft.

The deposit has been mined by a large open-cut 200 ft. wide extending into the hill, the summit of the hill being 500 ft. higher than the elevation of the open-cut. Interspersed with the feldspar are deposits of silica, which is sorted from the spar when mined.

The spar is loaded into cars which are trammed to an inclined chute, thence to a loading bin at base of the hill. The feldspar and silica, after being sorted, are trucked to the company's grinding plant



Screening and sorting plant, Campo Feldspar Deposit. Standard Sanitary Manufacturing Co., San Francisco, Calif.

located about 4 miles south on a siding of the San Diego & Arizona Eastern Railroad.

This property has been in continuous operation for the past fifteen years and has produced a considerable tonnage of both feldspar and silica. The company also purchases feldspar delivered to the grinding plant by small feldspar mines in the vicinity.

Feldspar Deposit north of Campo.

Mill building housing grinding plant on railroad east of Campo.

Mining equipment consists of gravity tramway; bunkers for waste and feldspar; one 4-drill, 2-stage compressor; pumping plant for water for engines and compressor.

Mill equipment consists of 16- by 10-in. Hercules crusher; elevator; Buhr stone mill; super high intensity magnetic separator; 14-in. separator (Gayco); two 5 by 22 ft. tube mills; one 6 ft. by 48 in. Hardinge mill; sacking machine; 240 h.p. diesel engine; electric generator.

This plant grinds 2 tons per hour to 200 mesh.

Bibl.: State Mineralogist's Rept. XXI, pp. 359-360.

Crestline Deposit is owned by L. B. Spaulding, Ramona, Cal. This deposit of feldspar and silica is located in Sec. 21, T. 16 S., R. 6 E., S. B. M.

It occurs in a pegmatite granite. A prospect shaft 10 ft. has been put down, exposing a good commercial grade of spar. Idle.

Dos Cabezas Feldspar Deposit. The owner is unknown. This is a large exposure of feldspar and silica occurring in various parts of Sec. 22, T. 16 S., R. 8 E., S. B. M.

These various deposits have not been developed to any extent, although there are good possibilities of securing a good commercial grade of both feldspar and silica reasonably close to a railroad siding.

Bibl.: State Mineralogist's Rept. XXI, p. 359.

Lookout Group is owned by Vincent Graner, Long Beach, Cal. This is a group of 4 claims known as Lookout No. 1, 2, 3 and 4, located in the NW. $\frac{1}{4}$ of Sec. 25, T. 9 S., R. 3 E., S. B. M.

The feldspar occurs in a pegmatite with a width of $2\frac{1}{2}$ ft. Improvements consist of 2 open-cuts 8 by 4 ft. by 4 ft. showing a commercial grade of feldspar. Idle.

Pearson Deposit is owned by A. N. Pearson, Aguanga, Cal., and located in Sec. 23, T. 9 S., R. 3 E., S. B. M.

This is a large deposit of high-grade feldspar and silica. It is located 4 miles south and 8 miles east of Oak Grove, on a patented homestead. It has been opened by a 6 by 8 ft. shaft and a 75-ft. open-cut. About 50 tons have been mined and piled on the dump. Idle.

Quality Deposit (Osborne Deposit) is owned by Mrs. R. C. Osborne, Campo, Calif., and located in Sec. 21, T. 18 S., R. 5 E., S. B. M., south of San Diego & Arizona Eastern Railroad Siding.

The deposit of feldspar and silica is 3 ft. wide. It has been developed by a 60-ft. shaft, 3 open-cuts and 2 shafts 10 ft. deep.

Bibl.: State Mineralogist's Rept. XXI, p. 359.

Spar King Mine is owned by H. E. Daugherty, San Diego. This feldspar and silica deposit is located in Sec. 13, T. 9 S., R. 2 W., S. B. M. The material is a good grade of orthoclase feldspar occurring in a vein from 2 to 6 ft. wide. Workings consist of 2 tunnels 80 and 30 ft. long. Idle.

Tom's Dream is owned by T. J. McCain, Boulevard, Cal., and located in the NE$\frac{1}{4}$ of Sec. 15, T. 17 S., R. 7 E., S. B. M.

This is a 2-ft. vein of orthoclase feldspar in schist, on the easterly slope of Eagle Peak, northwest of Tula Mountain; has been slightly developed with open-cuts.

The property is under lease. Idle.

FULLER'S EARTH

A deposit of montmorillonite, locally known as Otaylite, occurs on the Moato Ranch, 3 miles east of Otay on the escarpment of Otay mesa. This property is owned by the *General Petroleum Co.*, of Los Angeles.

The deposit has been opened up for a distance of 1000 ft., exposing a 20-ft. bank above the floor of the cut. The material has an unctuous feel, and is brown, white and pink in color. When it is left in contact with the air it breaks down into a powder. The stratum has a width of 6 to 8 ft., overlain by sandstone and soil 10 ft. thick. The property has been idle for some time.

Bibl.: State Mineralogist's Rept. XXI, p. 360.

GEMS

Regarding its deposits of semi-precious gems and gem materials, it is important to state that in point of variety and production San Diego County ranks fourth in the world. Moreover, it was here that the gem, kunzite, was first discovered.

The largest producing areas are in a series of pegmatite dikes which run northward from Mesa Grande through Pala and into Riverside County. They occur principally in three small mountains north and east of Pala Village, an Indian reservation about 28 miles east of Oceanside. The elevation is 1000 to 1800 ft. above the plain of San Luis Rey River. In that locality tourmalines have been found in quantity and the first specimen of kunzite was discovered. Another gem of particular interest produced in the region was a deep-blue topaz which, when cut, weighed 17 carats and is valued at more than $3000. One specimen of beryl weighed two pounds.

The tourmalines and beryls are invariably found associated with lithium phosphate (amblygonite) sometimes occurring in clay gouges outside of the vein matter.

Gem mines east of Ramona have produced sky-blue and sea-green aquamarines of value. Garnets have been recovered from claims east of Jacumba, Ramona and San Vicente.

The list of San Diego County gems and gem materials is large, comprising 17 species which have been arranged in two groups: (a) those of commercial interest and (b) those not yet commercially important.

The first discovery of gem stones in San Diego County was made in 1880 by Indian school children while at play. In 1892, C. R. Orcutt identified as tourmaline his discovery of gem materials at Pala but it was not until 1902 and 1903 that a succession of important discoveries on Heriart, Pala Chief and Aguanga mountains was made. J. W. Ware, of San Diego, the late Frank A. Salmons and M. M. Sickler, of Pala, have been among the most active developers of gem resources of the county.

The production of gem materials in San Diego County from 1900 to 1923 totaled $1,385,780, since which time it has been materially increased.

Shortly after the mines were exploited, the Dowager Empress of China had popularized the red tourmaline as a sacred stone, with the result that an extensive market for this gem was created in the Orient. However, after her death and disturbed economic conditions, the China market virtually was lost.

Numerous conditions arise to affect the gem market and cause wide fluctuations in demand. Changing fashions, the development of synthetic gems for use in low-priced costume jewelry and the changes in economic conditions influence the market for gems. The present market is found largely among well-to-do classes of residents and tourists, collectors and museums. The market for choice specimens of kunzite and topaz remains steady. The other gems, though beautiful, are not in active demand.

For technical description of the gem materials of San Diego County, the reader is referred to Bull. 37 (1905) of the State Mining Bureau, by Dr. George F. Kunz, nationally recognized as an authority on gems, who made a survey of this region in the early 1890's. The gem, kunzite, later was named after him. It occurs in lilac, pale pink, and white colors.

The tourmaline which derives its name from a dialect Cingalese word, turmali, used on the Island of Ceylon, is remarkable for its varied forms and colors. It may be bi-colored, tri-colored, etc. It occurs in green, pink, blue, colorless and a wide variety of shades. The colors may run through and through or the exterior and interior may be differently colored. In the pencil-shaped form three or more layers of colors may run from end to end. In well-defined crystal shapes, the stone possesses pyro-electricity, one end having attractive and the other having repelling force. Blue tourmalines are called indicolite, pink are called rubellite and the colorless are called achroite.

Beryls occur in five colors, crystalline quartz in five colors and chalcedony in two colors.

A gem stone grading less than 6.5 degrees hardness, according to the Moh scale, is valueless to the lapidary. The topaz grades 8, the kunzite, beryls and spinel grade 7.5 to 8 and the tourmalines and garnets grade 7.5.

In San Diego County there are 25 gem properties in various stages of development and production.

A. B. C. Gem Mine is owned by L. B. Spaulding, et al, San Diego, and located in the NW. $\frac{1}{4}$ of Sec. 8, T. 13 S., R. 2 W., S. B. M.

The zone in which the gems are found is a pegmatite in granite. The property is noted for its former production of pink beryl. These gems are usually found in the clay gouge alongside of the vein as is the case of most of the beryl found in other gem mines of the county. The property is developed by an inclined shaft on the vein. Idle.

Bibl.: State Mineralogist's Reports XIV, pp. 693-702; XXI, p. 362; Bull. 37, pp. 140-142.

Blue Bell Mine is owned by A. N. Pearson, Aguanga, Cal., and located in Sec. 12, T. 9 S., R. 3 E., S. B. M., 4 miles south and 8 miles east of Oak Grove.

This is a characteristic feldspar and silica pegmatite in which blue tourmaline is found. A good commercial grade of orthoclase has been uncovered in doing the assessment work. Idle.

Ed. Fletcher, Jr. Mine is owned by Ed. Fletcher, Jr., 1018 Ninth Ave., San Diego, Cal. This is a patented mine, adjoining the Tourmaline King Mine, north of Pala. The vein matter consists of lepidolite in which is found tourmaline. Idle.

Elinor Mine is claimed by I. S. Margolis, San Diego, Cal. This property was formerly known as the French Pete Mine. The vein consists of lepidolite, containing tourmaline. It is developed by two shafts and two tunnels. Shafts are caved. It is reputed to have produced about $5,000 worth of tourmaline.

Emeralite No. 2 Mine is owned by J. W. Ware, 1060 Sixth Ave., San Diego, and located 8 miles south and 6½ miles west of Oak Grove, in Sec. 10, T. 10 S., R. 2 E., S. B. M. Emeralite No. 2 Mine, formerly the Mountain Lily, is a patented claim, located on the southeast crest of Aguanga Mountain.

The vein is a badly faulted pegmatite containing the gem minerals blue topaz, tourmaline (nile green, green and blue), beryl (morganite, white and light blue). The vein occurs as a blanket about 3 ft. thick.

Developed by adit tunnels, whence about 2700 ft. of branching tunnels have been run to work the blanket vein. The property is worked intermittently.

Gem Star Mine is owned by M. M. Sickler, et al, Oceanside, Cal. This mine consists of one claim in Sec. 24, T. 9 S., R 2 W., S. B. M., 2½ miles northeast of Pala.

This property is essentially a tourmaline deposit, the gems occurring in a lepidolite vein 2 to 3 ft. wide. Workings consist of two tunnels, 150 and 70 ft. long, and an open-cut. Idle.

Green Cabin Mine is owned by L. H. Doss, Valley Center, Cal., and located in Sec. 14, T 9 S., R 2 W., S. B. M.

Workings consist of two tunnels, 30 and 35 ft., open-cut and a smaller shaft 15 ft. deep. The work has been done on a pegmatite vein consisting of lepidolite, feldspar and mica, carrying tourmaline. Idle.

Hercules Group is owned by W. H. Davis, 1872 E. Mountain St., Pasadena, Cal. This is a group of two claims, Hercules and Beryl, located in Sec. 8, T. 13 S., R. 2 E., S. B. M., 5 miles east of Ramona, on the old county road.

The mineralized zone consists of a pegmatite with vein matter about 12 in. wide in which is found tourmaline and beryl. Development consists of a 200-ft. tunnel and a 50-ft. tunnel on the vein. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 362.

Himalaya Mine. Lessee, Estate of Tom Quinn, 530 Fourth Ave., San Diego, Cal. This property is located 5 miles northwest of Mesa Grande, and is patented.

A large pegmatite dike containing tourmaline occurs on this property. Workings consist of 4 shafts and 7 tunnels. A bunkhouse and cottage are on the property. This mine has been a large producer of tourmaline, both rubellite and emeralite.

Mack Mine is owned by Felix Calac, 745 N. Sixth St., Escondido, Cal., and located in the SW. $\frac{1}{4}$ of Sec. 25, T. 10 S., R. 1 W., S. B. M.

This mine is located on land which was patented Nov. 3, 1891, by Felix Calac, the present owner. (Patent Cert. No. 4052) The mine was opened and worked by J. M. Mack under terms of a special agreement with the owner. It produced a very fine quality of aquamarines.

Workings consist of 7 open-cuts.

Pala Chief Group is owned by Mildred Wear and Margaret Moore, Pala, Cal. This is a group of 6 claims located in Sec. 13, 14, 23 and 24, T. 9 S., R. 2 W., S. B. M., northeast of Pala, and comprises the Pala Chief, Ocean View, Goddess, Knickerbocker, Little Wedge and Hazel W.

The Pala Chief is the largest gem producer of the group, yielding red and green tourmaline, kunzite and some beryl. The gem material occurs in a pegmatite dike, with a dark, hornblende-diorite, hanging-wall and a biotite-granite foot-wall, associated minerals in the pegmatite being lepidolite, muscovite and feldspar. The Pala Chief dike is the largest of all the gem-bearing pegmatite dikes in the county. Its width varies from 30 to 50 ft.; dip about 15° W.

Development work consists of two tunnels. The other claims of the group have been opened up by small, prospecting pits. Idle.

Bibl.: State Mineralogist's Reports XIV, pp. 691, 693, 694, 696, 697, 707; XXI, pp. 362-363; Bull. 37, pp. 25, 31, 55, 60, 61, 87, 126, 127.

San Diego Mine is owned by *Rynerson Mining Co.*, 4088 First Ave., San Diego, Cal., and located about 5 miles northwest of Mesa Grande. The property is patented.

The pegmatite vein is between walls of granite and contains tourmaline. Development consists of 140-ft. shaft on the vein. A gas hoist; shed 10- by 12-ft.; 600 ft. of track; and one ore car are on the property. Two men are working.

Sickler Group is owned by M. M. Sickler, 208 W. 54 St., Los Angeles. This group of 7 claims is located in Sec. 24, T. 9 S., R. 2 W., S. B. M., on Heriart Mountain.

The mineralized zone consists of a number of pegmatite dikes that vary in direction and dip. The property has been opened up by tunnels and open-cuts in ten locations. Veins vary from 2 to 4 ft. in width. The gem materials found are tourmaline and kunzite in lepidolite. On this property the first discovery of kunzite in the county was made.

Bibl.: State Mineralogist's Rept. XXI, p. 363.

Sonny Boy Mine is owned by Edward Richmond, 2857 K St., San Diego, Cal., and is located in Sec. 8, T. 13 S., R. 2 E., S. B. M., 5 miles east of Ramona.

The pegmatite dike on this property strikes E. and W. and has been opened up by a 50-ft. tunnel. Tourmaline is found in the vein matter. Idle.

Stewart Mine. The ownership is in litigation. Blanche C. Crane, of San Diego, is claimant in application for patent. This property consists of one claim located in the NW. $\frac{1}{4}$ of Sec 23, T. 9 S., R. 2 W., S. B. M.

This property is essentially a lithia deposit, the largest in the West. The vein strikes NW. and dips SW. The mine is developed by a shaft and tunnel. The vein matter is practically all lepidolite, with pockets of amblygonite occurring at times. Tourmaline is also found in the vein.

Equipment consists of ore bunker; blacksmith shop; 2 ore cars; and 300 ft. of track. Idle.

Bibl.: State Mineralogist's Rept. XXI, pp. 373-374.

Tourmaline King Mine is owned by R. M. Wilke, Palo Alto, Cal. This is a patented claim located in Sec. 14 and 15, T. 9 S., R. 2 W., S. B. M., north of the Tourmaline Queen Mine.

The mineralized zone consists of a pegmatite dike about 7 ft. wide that parallels the Tourmaline Queen dike. The minerals found in the dike are lepidolite, beryl, tourmaline and kunzite. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 363; Dr. George F. Kunz. Bull. 37, p. 129.

Tourmaline Queen Group is owned by Mildred Wear and Margaret Moore, Pala, Cal. This group consists of 5 claims known as Tourmaline Queen No. 1 and No. 2, Pala King, F. A. Salmons and Homestake, located in Sec. 14 and 15, T. 9 S., R. 2 W., S. B. M.

The Tourmaline Queen No. 1 and No. 2 claims are at the top of Tourmaline Queen Mountain, 6 miles east of Pala. The workings on Tourmaline Queen No. 1 are quite extensive on the pegmatite dike extending north from the Stewart Mine. This dike can be traced for 3000 ft. on the surface. It strikes NW. and dips 15° SW. The gems produced are beryl, tourmaline and kunzite. This mine has been a large producer of gem material in the past.

On the other claims of this group a number of test pits and open-cuts have been made on the various claims but no production of gems has resulted. On the Homestake claim there is a small vein of lepidolite, showing in both of the open-cuts on either side of the hill.

There is a flowing spring on the Tourmaline Queen No. 1 claim.

Bibl.: State Mineralogist's Rept. XXI, p. 363; Dr. George F. Kunz. Bull. 37, p. 127-129.

GRANITE

Granites of a number of varieties and colors occur in various locations in the county. The principal deposits are at Lakeside, Escondido and Santee. At Lakeside is a fine-grained granite of uniform texture and color known as silver-gray. Near Santee are quarries of silver-gray and bluish-gray granite that are suitable for monumental and building stone.

West of Escondido are deposits of dark hornblende-diorite. This "black granite" takes a fine polish and is used as an ornamental stone.

Black Diamond is owned by *Pacific Cut Stone & Granite Co.*, 414 S. Marengo Ave., Alhambra, Cal., and located in the W½ of the SW. ¼ of the NE. ¼ of Sec. 30, T. 12 S., R. 2 W., S. B. M., 7 miles south of Escondido.

This deposit consists of 30 acres and is located on patented land. There are two open quarries. The largest is about 150 ft. wide and the other is an open-cut 100 ft. back to face. The product is a black, fine grain, even texture hornblende-diorite that takes a resplendent polish. Large blocks have been shipped but bulk of production consists of monumental blocks secured from boulders that occur on top of outcrop.

Equipment consists of two large derricks and hoist, air compressor, all electrically driven. Four men are employed.

Crystal Black Granite Quarry is owned by John Studeburg, Escondido, Cal., and located on the NW. ¼ of SE. ¼ of Sec. 30, T. 12 S., R. 2 W., S. B. M., 7 miles south of Escondido, Cal.

This is an open quarry on patented land. It produces the best quality of Escondido black granite which is used largely for markers in cemeteries. It is a fine-grained, deep black granite which takes a high polish. The production is about 2000 cu. ft. per year.

Ebony Black Granite Quarry is owned by Wm. Hike, Escondido, Cal., and located in the SE. ¼ of the SW. ¼ of the NE. ¼ of Sec. 30, T. 12 S., R. 2 W., S. B. M., 7 miles south of Escondido. The property is patented. It is leased to *Pacific Cut Stone & Granite Co.*, Alhambra, Cal.

This is a deposit of black granite one-quarter of a mile wide. Workings consist of a large open-cut. Equipped with two derricks and a compressor.

McKoon Quarry is owned by Hosmer McKoon, Lakeside, Cal., and located in Sec. 10, T. 15 S., R. 1 W., S. B. M., 2 miles west of Lakeside. A tract of 850 acres of land on which this property is located is patented.

Large blocks of silver-gray granite of even texture and color are obtainable. The deposit lies near the summit of a range of low hills north of El Cajon Valley. The belt of granite, 600 ft. wide, can be traced for about one mile along its strike which is N. by NW. The granite face is exposed for more than 200 ft. in length and 75 ft. in height. The material takes a very high polish and is much in demand for monumental work. On the hill west of the quarry are large boulders of light gray granite useful for dimension material. It has a remarkably straight fracture and can be easily obtained in rectangular blocks as large as can be handled.

Bibl.: State Mineralogist's Rept. XXI, p. 367.

Rossi Quarry is owned by Dan F. Rossi, 3845 Imperial Ave., San Diego, and located in Sec. 3, T. 15 S., R. 1 W., S. B. M., 1½ miles west of Foster. This is a patented property.

The product is a light silver-gray granite, most of the material coming from massive boulders and is used for monumental purposes at the owner's monument works in San Diego. The quarry has been opened on two benches or levels.

Bibl.: State Mineralogist's Rept. XXI, p. 367.

GRAPHITE

There has been no exploitation of graphite in the county. This mineral occurs at Mason Valley in ledge form and is found in the schists at Julian where it interferes with gold recovery by amalgamation.

Mary Jane Mine (Kane) is owned by Guy Urquahart, 1041 Columbia St., San Diego, Cal., and is located in Sec. 10, T. 14 S., R. 5 E., S. B. M.

This deposit of graphite is located on a patented claim. The ore shows gold values. The property has been developed by 3 tunnels, 60, 84 and 96 ft. in length. There is a shaft 50 ft. deep and a 12-ft. open-cut. The material is suitable for foundry facing and paint stock.

Bibl.: State Mineralogist's Rept., p. 369.

GYPSUM

There is only one location in the county where gypsum occurs. This outcrop is extensive. Distance to railroad and the lack of a road to the location are drawbacks to the exploitation of the deposit.

Blanc Gypsum Deposit is owned by Sylvester Kipp, San Diego. This is a patented property located in Sec. 24, T. 13 S., R. 8 E., S. B. M., about 800 ft. west of the east county line.

The material occurs in a bluff on the north side of Carriso Wash, varying from 20 to 40 ft. in thickness. The length of the exposure is about 1000 ft.

LIMESTONE AND MARBLE

Crystalline limestone occurs in several areas in the eastern part of the county. There are extensive deposits of limestone in the vicinity of Dos Cabezas, a station on the San Diego and Arizona Eastern Railroad. A large deposit of white limestone of marble grade, occurs at Verruga Valley southeast of Warner Hot Springs. Transportation cost to market is the drawback to the exploitation of these materials.

Heathman Quarry is owned by R. W. Heathman, 3799 Park Blvd., San Diego, Cal., and located in Sec. 27, T. 16 S., R. 8 E., S. B. M., one mile north of Dos Cabezas Siding, on the San Diego and Arizona Eastern Railroad.

This is a deposit of white limestone 10 ft. wide; strike NW., dip vertical. This property has been mined by open pit 50 by 30 ft. About 30 tons are piled up for shipment. Equipment consists of 15-h.p. gas engine and compressor.

Bibl.: State Mineralogist's Rept. XXI, p. 370.

Lakeside Lime and Marl is owned by W. A. Meyer, Lakeside, Cal., and located in Sec. 1 and 2, T. 15 S., R. 1 W., S. B. M., 2 miles north of Lakeside.

This is a deposit of agricultural lime, grading medium to high. It is used as a fertilizer by farmers and fruit growers of the local region. Calcareous layers from 2 to 4 ft. thick occur on 400 acres of the land, known as El Cajon Rancho and located 2 miles north of Lakeside.

A determination made of the lime carbonate by the Department of Agriculture of the State of California, showed 83.7% $CaCO_3$. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 373.

Verruga Quarry is owned by John Johnston, Escondido, Cal., and located in Sec. 10, T. 11 S., R. 4 E., S. B. M., 21 miles northeast of Santa Ysabel. The deposit comprises 8 patented claims located one mile north of Verruga Post Office.

The west outcrop is 100 ft. wide and about 1000 ft. long along its strike. The east deposit is about 200 ft. wide and traceable on the surface for about 1000 ft. Quarrying has been done on both deposits but mostly on the west deposit. Large blocks of hard, white, coarse marble are obtainable. The marble has been extensively used in some of the large buildings in San Diego. The quarries were closed on account of cost of transportation to a railroad shipping point but since new highways have been built the product can be put aboard cars for about $2.50, the former cost having been $8. Idle.

Bibl.: State Mineralogist's Rept. XXI, p. 372.

LITHIA

Two ores of lithia are found in the pegmatite dikes in the northern part of the county, particularly at Pala and Mesa Grande. The principal ore, lepidolite, has been mined since 1899. Associated with the lepidolite deposits are occasionally found pockets of amblygonite, a lithium phosphate. These two minerals are used in glass manufacturing, fireworks, medicines, and the chloride in air-conditioning.

Royal Mine is located southeast of Banner, in Sec. 18, T. 13 S., R. 5 E., S. B. M. This property is idle.

San Diego, Himalaya and Esmeralda Mines at Mesa Grande have produced small quantities of lepidolite.

On the east slope of Tourmaline Queen Mountain, north of Pala, is exposed a pegmatite dike 35 to 60 ft. wide, striking north with dip west 10°. This exposure is traceable for more than one-half of a mile from north to south and has been opened by cuts at various points.

Stewart Mine consists of one claim, located in Sec. 23, T. 9 S., R. 2 W., S. B. M., one mile north of Pala.

The vein strike is NW. to SE. and the dip W. In places, the vein is 60 ft. wide. This is the largest deposit of the ores of lepidolite and amblygonite in the West. The property has been extensively worked in the past but due to litigation as to title, it has been inoper-

ative for twelve years. Application for patent is pending and it is expected that operation will again be resumed this year.

Other occurrences at Pala are in the Tourmaline Queen, Pala Chief, Sickler and Tourmaline King mines.

Bibl.: State Mineralogist's Reports XIV, pp. 706-708; XXI, pp. 373-374; S. M. B. Bull. 37, pp. 124-133.

MICA

Muscovite mica occurs at Mica Springs about 10 miles northeast of Jacumba on Highway No. 80. The outcrop is a pegmatite dike of quartz and feldspar (orthoclase), occurring in granite.

Twenty claims have been located in this locality. Small shipments have been made of hand-sorted scrap mica to a grinding plant at Los Angeles. It may be profitable to exploit this deposit by hand-sorting the three minerals contained in the pegmatite.

MINERAL PAINT

Several deposits of material suitable for paint pigments occur in San Diego County, notably brown oxide of iron, yellow oxide of iron (ochre) and palagonite. Northwest of Jacumba, near Mica Springs, is an outcropping on the escarpment of a high hill of reddish-brown oxide suitable for umber.

On the Agua Caliente Indian Reservation northwest of Warner Hot Springs is a 4-ft. vein of hydrated oxide of iron suitable for the uses of ochre. This deposit is said to carry gold values.

Palagonite Group is owned by F. P. Jansen, Los Angeles. This property consists of 3 mining claims (patented) located in Sec. 3 and 10, T. 3 S., R. 3 W., S. B. M. The claims are known as the White Hawk, Ocean View and Pinite Queen, and are located 8 miles northeast of Encinitas.

The deposits consist of a wide belt varying from 70 to 100 ft. wide and traceable for about 4000 ft. on the surface; strike E., dip about 45° N. The hanging wall is basalt, footwall is diorite. The material, locally known as pinite, is greasy to the feel, rather soft and texture is fine-grained, resembling serpentine. Near the footwall, its color is reddish and yellowish, grading to a light shade toward the hanging wall.

The property is developed by 3 tunnels of 107, 70 and 40 ft. in length, with several cuts and test pits. Most of the work was done by the former operators, the Palagonite Mining Co., of Oakland, Calif. The property is now in litigation.

Bibl.: State Mineralogist's Reports XIV, pp. 668-691; XXI, p. 374.

MINERAL SPRINGS

In a highly mineralized zone like San Diego County, favored with adequate precipitation of moisture, it is natural that mineral springs should exist. They occur in various localities in the mountains, the valleys and even close to the seashore. The waters from them show

various properties, and their temperatures vary from cold to as high as 139° F.

Traditionally and historically, the Indians, for an unknown period of time, recognized curative properties in water from some of the springs and used it for that purpose. From the scum of springs bearing iron, sulphur, or other minerals, they obtained red and yellow dyes for tattooing their bodies and decorating their arts. Interesting and colorful legends are associated with some of the springs.

Since occupancy of the region by white men, adaptation of the mineralized waters for healthful and for beverage purposes has continued. It is reflected in the development of resort and recreation centers and to some extent, in the marketing of natural mineralized waters on a large scale. In the early 1900's water from one of the springs was bottled and shipped in carload lots to national and international markets. In recent years the springs have been exploited largely as resort and recreation centers and in that capacity they contribute a substantial annual income, the extent of which can not be even approximated.

Borrego Springs are located in Sec. 17, T. 11 S., R. 7 E., S. B. M., about 33 miles by road northeast of Julian, on the west bank of Borrego Wash, at the western edge of the Colorado Desert. The water is alkaline, but usable. Mesquite trees, willow, rush and salt grass grow near the spring and in the valley below. An old cabin nearby marks the position of the spring.

Bradley Spring is located 6 miles north of the abandoned railroad station of Foster.

Water from this spring which occurs at an elevation of 1775 feet, issues from the base of a granitic boulder in a steep ravine. It is collected in a cemented reservoir, piped to a storage tank at the roadside, then bottled and sent to San Diego as a table water.

Buckman Springs are owned by J. T. Hayden and located in Sec. 20, T. 16 S., R. 5 E., S. B. M.

These springs flow at an elevation of 3400 ft. The group consists of 6 small, naturally carbonated springs, high in lithia content, producing about 5 gallons of water per minute. Temperature of the water is 60 to 65°, with a sweetish taste. The water, charged with natural carbonic gas, was formerly bottled and shipped in large quantities. The springs are located 52 miles east of San Diego on U. S. Highway No. 80.

El Granito Mineral Springs are located in Sec. 14, T. 16 S., R. 1 W., S. B. M.

These springs are about one mile southeast of El Cajon. In early times the waters from them were used by the Indians extensively to regulate digestive functions. The spring occurs at 500 ft. elevation, has a temperature of 62° F. and flows about 3 gallons per minute.

Jacumba Hot Springs are owned by B. L. Vaughn, Jacumba, Calif., and located between Sec. 7 and 8, T. 18 S., R. 8 E., about a quarter of a mile north of monument No. 233 of the international boundary.

These springs include one of cold water and several that yield waters with temperature ranging from 86° to 98° F. The total yield is about 15 gallons per minute. They show a strong mineral content and are regarded as having medicinal value. A bath house and other accommodations are provided for patrons. Jacumba is located 76 miles east of San Diego on U. S. 80.

Nuvida Well is owned by the Nuvida Water Co., San Diego, Cal., and located about 10 miles east of San Diego, near Sweetwater Spring.

About 1908 this well was dug largely to catch seepage waters from Sweetwater Spring nearby. It operated commercially for a time but in recent years it has been dormant.

San Miguel Spring is owned by San Miguel Springs Water Co., 831 E St., San Diego, Cal., and is located near the southern foot of San Miguel Mountain about 15 miles east of San Diego.

Prior to and during the Mission era of California history an Indian village was located near this spring. The Indians ascribed curative properties to its waters which are quite heavily mineralized. The water is now being bottled and sold largely as a table water. The water is sold under the trade name of *Visaqua* (water of life).

Sweetwater Springs are owned by E. J. Hansen, La Mesa, Cal., and located about 10 miles east of San Diego. (Known also as *Jamacha, Isham's Baldhead* and other names.)

Warner's Hot Springs are owned by Sid Furze, and located 68 miles northeast of San Diego.

These springs are located near the site of the ancient village of Kupa, the home village of the Cupeno (or Agua Caliente) Indians. They are at the northeastern margin of a Mexican grant known as San José del Valle. In 1831 the property was acquired by J. J. Warner, whose trading post is linked with the military expedition of General Kearny, the old Butterfield Trail, the last Indian insurrection in San Diego County and other events of historic interest. The 6 springs are at an elevation of 3150 ft. and discharge about 150 gallons a minute of highly mineralized water, having a temperature of 131° to 139° F. Developed as a resort center, providing hotel accommodations, cabins and camp sites, the springs are well patronized by seekers of health and recreation.

NOTE.—For chemical analysis of water produced by these springs, consult State Mineralogist's Rept. XIV, pp. 717-722; U. S. Geol. Survey Water Supply Paper 338, Springs of Calif., U. S. Geol. Survey Water Supply Paper 224, pp. 84-87.

SALT

At the south end of San Diego Bay about forty salt ponds covering approximately 1400 acres have been in operation for some years, producing common salt (sodium chloride) by solar evaporation. The owner is *Western Salt Co.,* San Diego, F. S. Babcock, president.

At high tide the water of the bay is admitted into these ponds and when filled the ponds are closed off by earth dams which hold the entrained water. The time of evaporation is dependent upon the atmospheric conditions, such as humidity and precipitation. During the evaporating period about 30,000 tons of salt are produced annually.

The salt gathered from the floor of the ponds is trucked to the treatment plant where the different grades are processed for market. The bitterns remaining in the ponds are pumped to a nearby chemical plant where the more soluble salts of magnesium and calcium are further recovered, bromine being also recovered.

Bibl.: State Mineralogist's Rept. XIV, pp. 713-715.

SAND, GRAVEL AND CRUSHED STONE

The sand and gravel industry of San Diego County centers in the beds of the Sweetwater, Otay and San Diego rivers. Sedimentary materials are dredged or pumped from the river beds, graded by a revolving screen, then dried and sold throughout the county for building and road construction purposes. In the quarry operations, rocks of size convenient for handling are crushed and graded according to the uses for which intended. The formations utilized are fine-grained felsite.

Canyon Rock Company's Plant. This sand and gravel plant is located in Mission Valley east of Grantville, about 800 ft. from the south bank of the San Diego River; owner, Canyon Rock Co., 3911 Fifth Ave., San Diego, Calif.

Sand and gravel is obtained from the river bed by dragline, whence the material is hauled by truck to the screening plant located near the highway. After having been screened to various sizes, the material is stacked in piles.

The company also maintains an asphalt mix plant near its screening plant.

All machinery is electric-driven. A recent fire destroyed the bins of the screening plant. An entire new plant is now in the course of construction about 1000 feet east of the present plant.

Daley Sand & Gravel Plant is owned by Daley Corp., 4430 Boundary St., San Diego, Cal., and located in Murphy Canyon, 9 miles north of San Diego.

Gravel pits worked by this company are in Murphy Canyon, north of the plant. Materials are transported to the hopper by scrapers and there loaded on side-dump cars and hauled to receiving bins. There it passes over revolving screens. The oversized from a 2-in. ring are passed through crushers of jaw and gyratory type, washed and re-graded. The plant is driven by electric motor of 100-h.p.

Also, the same firm has a sand and gravel plant at the foot of Ward's Road on the San Diego River. This plant obtains its materials from the bed of the San Diego River.

Bibl.: State Mineralogist's Rept. XXI, p. 377.

Fenton Material Co., 1245 National Ave., San Diego, Calif. This company operates 3 plants, located in Chollas Valley, Murray Canyon and Otay. A quarry at Spring Valley is now idle.

Chollas Valley Plant is located 3 miles east of San Diego. The materials produced are crushed cobbles and gravel from canyon wash;

capacity, about 250 yards per day. The equipment consists of conveyors, crushers and revolving screens; operated by 100-h.p. electric motor.

Otay Plant is located near the town of Otay, in Sec. 22 and 23, T. 18 S., R. 2 W., S. B. M. The company controls 160 acres along the bed of Otay River. A spur track of the San Diego & Arizona Eastern Railroad provides railroad transportation. Material from the river bed is deposited by bucket hoist into side-dump cars and hauled to the plant. Here it is dumped over grizzly bars of railroad iron spaced 9 in. apart. The minus 8-in. goes into a steel hopper from which it passes on a belt conveyor to a 4-in. grizzly. From this grizzly, the over-size passes to an Austin crusher and the through-size goes to a revolving screen with 2-in. ring, where the minus 2-in. material is washed and re-graded. Sand of two grades is produced, a coarse sand for concrete and a fine sand for mortar. Material of one and 2-in. size is transported to the material yard. Capacity of the plant is about 1000 tons per day; electric power, 220-h.p. Idle.

Murray Canyon Plant. This property, comprising 160 acres extending north along Murray Canyon, is located about 5 miles north of San Diego. From banks along the canyon, the material is loaded on side-dump cars and hauled to the plant where it is dumped over a 12-in. grizzly to the hopper. The minus 12-in. material is conveyed by belt to a Wheeling crusher and crushed to pass a 3-in. ring. The minus 3-in. product is then screened to 2-in. size, all oversize being crushed, re-screened and washed. The quarried rock contains considerable clay and the washing plant consumes 600 gallons of water per minute. Water for the plant is pumped from 6 wells in Mission Valley. The plant has a capacity of 1000 tons per day. Operation requires 240-h.p. Idle.

Spring Valley Quarry. The formation of this quarry consists of a fine-grained, hard felsite, forming a hill north of Lemon Grove on a branch line of the San Diego & Arizona Eastern Railroad. The quarry face is 250 ft. in length and about 100 ft. above the floor. When this plant was in operation 500 tons of crushed stone were produced daily. Most of the equipment has been removed. Bunkers still in place. It is now idle.

Bibl.: State Mineralogist's Rept. XXI, pp. 377-379.

Nelson & Sloan Gravel Plant is owned by M. L. Nelson and F. R. Sloan, Chula Vista. The plant is located on the Otay River, near the town of Otay. The plant is operated by electric power and has a production capacity of about 200 cu. yd. of washed sand and gravel per day.

Bibl.; State Minerologist's Rept. XXI, p. 379.

GREEN STONE

Calavara Rock Quarry is owned by Calavara Rock Co., Oceanside, Cal., S. G. Getty, superintendent. It is located 3½ miles east of Rancho Santa Fe post office and is patented.

This quarry consists of fine-grained rhyolite about 100 ft. wide, with walls 40 ft. high. The material, locally known as greenstone is shipped for preparation of roofing-paper granules. About 3 cars a week are being produced.

Carmean Quarry is owned by P. Carmean, Whittier, Cal., and located 3½ miles east of Rancho Santa Fe post office. It is patented.

On this property is a 150-ft. vein of fine-grained "greenstone" (felsite). Workings consist of an open quarry about 150 ft. long by 40 to 60 ft. wide.

Shipments are being made to Los Angeles for preparation of roofing granules.

Green Stone Quarry is owned by G. L. Dodds, Escondido, Cal., and located near the center line between Sec. 11 and 12, T. 13 S., R. 3 W., S. B. M.

The deposit consists of a fine-grain, green rock of even texture and color. Outcrop 400 ft. wide, opened by cuts and trenches. The material is used as the green rock covering for roofing paper. Idle.

SILICA

There are a number of deposits of silica in San Diego County. Freedom of the silica from iron, mica and other contaminating minerals makes it suitable for use with feldspar for glazes for porcelain ware, enamel wares, pottery, and tile. The principal deposits are located near Campo, Jacumba, Jewell Valley, Ramona, Lakeside, and Escondido.

Shipments are being made intermittently from some of the deposits.

Crystal Silica Co. Mine is owned by Crystal Silica Co., 656 East 61 St., Los Angeles, and located at Talica Station, on the Escondido Branch of the A. T. & S. F. Railroad. It is patented property.

This a large open-cut quarry of silica sand from 10-mesh to 60-mesh classification, handled by simple quarry work. All material is conveyed by tractor to the mill, where it is washed, dried, classified, sacked and loaded on cars. The five grades of marketed product are used respectively, for filtering, blast sand, exterior stucco, interior stucco and playground sand, and stucco filler and cement waterproof. The production is about 15 cars per month.

Lillian Fanning Ranch is owned by Lillian Fanning, Boulevard, Cal., and located in Jewell Valley, S. ½ of Sec. 4, T. 18 S., R. 7 E., S. B. M.

This is an outcropping of white silica (quartz) 15 ft. wide and 50 ft. long. Some surface work has been done.

Risley Mine (Burroughs Silica Mine) is owned by C. W. Risley, Electric Bldg., San Diego, Cal., and located in Sec. 8, T. 18 S., R. 7 E., S. B. M.

This is a wide vein of white silica (quartz) standing vertically, 20 ft. wide and 50 ft. long. A tunnel 36 ft. long enters the deposit from the north side. This deposit is located within three-fourths of a mile from railroad. Shipments are being made to Los Angeles.

Bibl.: State Mineralogist's Rept. XXI, p. 375.

Walker Quartz Mining Claim is owned by Estate of John R. Walker, San Diego, and is located in Sec. 32, T. 17 S., R. 7 E., S. B. M. This property is patented.

It is an 8-ft. vein of silica. Workings consist of 3 open-cuts.

SILLIMANITE-ANDALUSITE-DUMORTEIRITE GROUP

Sillimanite and andalusite are both aluminum silicates (Al_2SiO_5), having the same composition and formula but with slightly different physical characteristics. Dumortierite, though differing somewhat in composition from the above, being a basic aluminum silicate ($H\ Al_8B\ Si_3O_{20}$), has proved similar in behavior in ceramic work so that it is now being mixed with andalusite for electrical porcelains.

Andalusite and dumortierite are utilized in the manufacture of porcelain for automobile spark plugs, for other high-tension electric insulators, laboratory ware and porcelain.

These minerals occur in San Diego County but no commercial deposits have been discovered. Pink, radiating masses of andalusite occur in quartz veins northeast of Pala.

Dehesa Dumortierite Deposit. Dumortierite occurs in a dike that cuts a biotite granite, a few miles east of Dehesa. The dike is about 900 ft. in length, with a thickness of about 40 ft., strikes E.-W.; dip 70° N. The upper part of this dike is a fine-grained rock, consisting of quartz and sillimanite, while the lower part is a coarse-grained rock composed of quartz and dumortierite. The color of the mineral is lavender. The dumortierite occurs in irregular masses and also in fan-shaped, radiating masses. This deposit may be of commercial importance.

Sillimanite occurs on a homestead owned by John A. MacCullough, Chicago, Ill., in Sec. 4 and 5, T. 16 S., R. 2 W., south of Alpine. The sillimanite occurs in quartz outcrop in granite that strikes northwest and is traceable on the surface for a considerable distance.

STRONTIANITE

Last Canyon Mine is owned by Malcolm L. Gilmore, Boulevard, Cal., and located about 5 miles northwest of Jacumba.

On this property there is a surface outcrop of strontianite 50 ft. wide. A small tunnel discloses a vein 40 in. wide. Strontianite is used in the manufacture of fireworks and red flares and in purifying sugar.

VOLCANIC ASH

The only known occurrence of volcanic ash in San Diego County is one large deposit in the Anza State Park. Transportation is a factor in the exploitation of this deposit.

Pompai Group, No. 1 to 4, is owned by J. M. Collins and J. S. Lang, Aguanga, Cal., and located in Sec. 24, T. 9 S., R. 5 E., S. B. M.

This is a large deposit of volcanic ash located in the northwestern end of Borego Valley. The deposit, varying in width from 16 in. to 30 ft. can be traced for one mile.

Volcanic ash is used as an abrasive and as a base in the manufacture of scouring and cleaning powders.

Volcanic ash deposit, Borego Valley.

PROSPECTS

The claims listed below are in the prospect stage, development work is being or has been carried on but no production has resulted yet. In some cases, properties have been abandoned.

Name of claim	*Location*	*Class of ore*	*Owner*
Anchor	Sec. 20, T. 15 S., R. 5 E.	Gold	Chas. P. Green
April Fool	Sec. 14, T. 13 S., R. 4 E.	Gold	E. R. Rousseau
Asper	Sec. 2, T. 13 S., R. 4 E.,	Gold	Otto Asper
Banner Horseshoe	Sec. 10 & 11, T. 13 S., R. 4 E.	Gold	Ada L. Critchett
Bengal No. 1, No. 2	Sec. 13, T. 15 S., R. 4 E.	Gold	Lawrence Record
Big Buck	Sec. 36, T. 9 S., R. 2 E.	Lithia	A. Molino
Black Canyon Spar	7 mi. NE. of Ramona, near road	Feldspar	L. B. Spaulding
Black Eagle	2½ mi. NE. of Mesa Grande	Gold	Dela Angel
Black Hawk Group 4 claims	5 mi. S. of Oak Grove and ¾ mi. E. of Warner's Springs	Gold	T. E. Wilson
Blue Bird	Sec. 11, T. 13 S., R. 4 E.	Gold	Earl J. Lusk
Butte	5 mi. SE. of Julian	Gold	Tony Floersch et al.
Butte No. 2	Sec. 5, T. 15 S., R. 5 E.	Gold	H. L. Neild
Carson Ranch	NW. ¼ of Sec. 10, T. 18 S., R. 8 E.	Pl. Gold	J. L. Shea Carson
Cash Entry Group 7 claims	Sec. 30-31, T. 14 S., R. 5 E.	Gold	W. R. Biggs
Charley K.	W. of Noble Canyon, T. 15 S., R. 5 E.	Gold	Chas. Keiser
Cimmeron	Sec. 20, T. 15 S., R. 5 E.	Gold	Mrs. Lillie E. Flegal
Dark Horse (Group)	Sec. 14, T. 13 S., R. 4 E.	Gold	L. Bittner
Deer Park (Group)	Sec. 31, T. 14 S., R. 5 E.	Gold	Dr. Frank Kaentz
Desert Queen	Sec. 22, T. 13 S., R. 8 E.	Manganese	H. W. Maddux
Doolittle Group	Sec. 16, T. 18 S., R. 2 E.	Gold	A. R. Majors
Elliott Mine	Sec. 31, T. 17 S., R. 8 E.	Feldspar	J. R. Elliott
Eureka Group	Sec. 23, T. 13 S., R. 4 E.	Gold	C. W. Cary
Fee	½ mi. SE. of Shiners Camp, Laguna Mountains	Gold	Harry Fee
Gold Luck	Sec. 11, T. 13 S., R. 4 E.	Gold	R. G. Melrose
Gold Standard	Sec. 10, T. 13 S., R. 4 E.	Gold	Mike Morani
Golden Crown	5 mi. SE. of Oak Grove	Gold	Mrs. T. E. Wilson
Golden Harp	Sec. 20, T. 15 S., R. 5 E.	Gold	Chas. Keiser
Golden Lola	Sec. 11, T. 13 S., R. 4 E.	Gold	Chas. Carey
Golden Lola Lode	Sec. 11, T. 13 S., R. 4 E.	Gold	Carey & Loock
Golden Star No. 1	Sec. 21, T. 17 S., R. 5 E.	Gold	R. E. Clark
Golden Stump	Recreation Area, Laguna Mountains	Gold	B. H. Fisher et al.
Golden Stump Ext. #1	Laguna Mountains	Garnet	J. N. Sexton
Good Shepard	Sec. 14, T. 13 S., R. 4 E.	Gold	J. D. Cotman
Grand View No. 1	Sec. 3, T. 17 S., R. 7 E.	Gold	Asa Freeman
Grapevine	Sec. 23, T. 13 S., R. 4 E.	Gold	H. Sharpless
Grubstake	Sec. 10, T. 11 S., R. 4 E.	Gold	James Fox
Herma	Sec. 4, T. 13 S., R. 4 E.	Gold	Herman Meyer
Home Builders Lode	Sec. 11, T. 13 S., R. 4 E.	Gold	Julia Loock
Ida Mae	3 mi. NE. of Mesa Grande	Gold	Louis A. Scholders

Name of claim	*Location*	*Class of ore*	*Owner*
Jacomba Copper Co., No. 1	Sec. 26, T. 17 S., R. 8 E.	Feldspar	J. R. Elliott
Jacques	Sec. 14, T. 13 S., R. 4 E.	Gold	Earl J. Lusk
Jatina	Sec. 20, T. 15 S., R. 5 E.	Gold	J. & T. Rasmusson
Kitty Kay Group	Sec. 17, T. 16 S., R. 5 E.	Gold	Guy Hogan
Ledge Lode	Sec. 31, T. 12 S., R. 4 E.	Gold	Chas. E. Sexton
Lucky Strike	Sec. 17, T. 16 S, R. 5 E.	Gold	T. Gill
Lucky Strike	Sec. 10, T. 11 S., R. 4 E.	Gold	Ralph Wagor
Lucky Strike	Sec 19, T. 9 S., R. 4 E.	Gold	W. D. Tungate
Macaboy	Sec. 5, T. 9 S., R. 3 E.	Gold	Mrs. Margaret Langley
Mamie	Sec. 27, T. 16 S., R. 8 E.	Limestone	R. W. Heathman
Manett (Melba Group)	Sec. 4, T. 15 S., R. 5 E.	Gold	J. C. Keyes
Mason Valley Gem	Mason Valley 1½ mi. W. of Co. Road	Lepidolite	D. G. Ingraham
Mercedes (Patented)	Sec. 4, T. 15 S., R. 5 E.	Gold	W. J. Bauerle
Mica Springs	Sec. 35, T. 17 S., R. 8 E.	Feldspar	Walter Horr
Morning Glory	Sec. 16, T. 16 S., R. 6 E.	Gold	L. B. Spaulding
Mother Lode	Sec. 17 & 20, T. 15 S., R. 5 E.	Gold	Kevahe J. McLauchlan
North Star Group	Sec. 31, T. 14 S., R. 5 E.	Gold	Dr. Steward
Old Ella Claims	Sec. 32 & 33, T. 12 S., R. 4 E.	Gold	Mrs. E. F. Bowen
Overlook	Sec. 21, T. 17 S., R. 8 E.	Gold	Stephen Bistram
Patton Lode	Sec. 19, T. 11 S., R. 2 E.	Feldspar	Mary L. Powers
Princess	Sec. 20, T. 15 S., R. 5 E.	Gold	Kevahe J. McLauchlan
Red Hill	3 mi. NE. of Mesa Grande	Gold	Dela Angel
Red Rooster	Sec. 17, T. 16 S., R. 5 E.	Gold	Guy Hogan
"76"	Sec. 10, T. 13 S., R. 4 E.	Gold	J. Hervey Johnson
Shenandoah	Sec. 23, T. 11 S., R. 2 E.	Gold	Arthur Stone
Silent King	Sec. 26, T. 15 S., R. 4 E.	Gold	Chas. Keiser
Silver Cloud (2 claims)	Sec. 20, T. 15 S., R. 5 E.	Gold	Mrs. L. E. Flegal
Thelma	Sec. 4, T. 15 S., R. 5 E.	Gold	W. J. Baurle
The Narrows	Borego Valley Road	Gold	H. W. Maddux
Truelsen's	Sec. 31, T. 12 S., R. 4 E.	Gold	D. S. Truelsen
Vernon Group 5 claims	Sec. 30 & 31, T. 14 S., R. 5 E.	Gold	Zoe Vernon
Yellow Bar	Sec. 26, T. 10 S., R. 5 E.	Gold	F. B. Osborne

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

In this Issue

For the past ten years Dr. Leo G. Hertlein and Dr. U. S. Grant, IV, have been working on the geology and paleontology of the Pliocene of San Diego County. Their familiarity with the western part of the county, and the relation of its geology to the oil possibilities, justified a request from the Geologic Branch for an article to be especially prepared for the California Journal of Mines and Geology. In publishing this paper, we wish to express our appreciation for the excellent contributions.

A much more expanded report covering details of geology and systematic paleontology (almost exclusively of the Pliocene of San Diego County) will appear as Memoir No. 2 of the San Diego Society of Natural History. This work was sponsored by the California Academy of Sciences, The San Diego Society of Natural History, and the University of California at Los Angeles. Also the investigation received personal donations from the authors and others.

In a Forth-coming Issue

In a forth-coming issue of the California Journal of Mines and Geology, there will be a report by Dr. Charles A. Anderson and Dr. R. Dana Russell on the Tertiary Formations of Northern Sacramento Valley. Both of these geologists have been extensively investigating the volcanics and the sediments of the Tertiary of this region since 1930.

This paper is another generous and fine contribution and we shall be very pleased to publish it, especially since it concerns a region on which little has been published recently, and oil and gas companies have shown increasing interest in the area.

GEOLOGY AND OIL POSSIBILITIES OF SOUTHWESTERN SAN DIEGO COUNTY

By Leo George Hertlein* and U. S. Grant, IV†

OUTLINE OF REPORT

INTRODUCTION

This paper presents a brief summary of the areal, stratigraphic, structural and economic geology of the southwestern part of San Diego County. The geologic map (fig. 2) shows the aerial geology of this region and the boundaries of the area covered by this report. Larger scale topographic maps are available in the topographic atlas of the U. S. Geological Survey (San Diego, La Jolla, El Cajon, and Cuyamaca quadrangles). As the authors are preparing a longer and more detailed geologic and paleontologic report on the San Diego region it has been considered unnecessary to include here a review of the previous literature or to discuss fully the physiography and paleontology.

PHYSIOGRAPHY

The land surface of the San Diego region consists almost entirely of a series of wave-cut marine terraces carved into horizontal or gently dipping marine Cretaceous, Eocene, and Pliocene conglomerates, sand-

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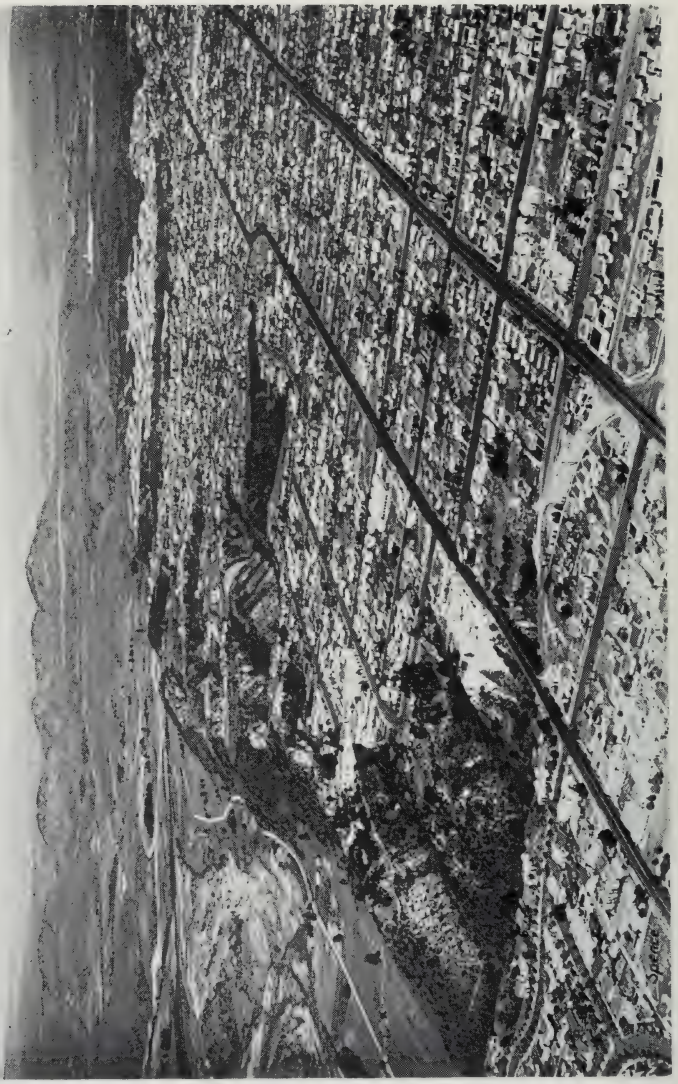

FIG. 1. View of a northern portion of the San Diego Mesa in the University Heights district, San Diego, California, looking northeasterly. The Mesa is a marine wave-cut terrace here truncating the Pliocene San Diego formation. The Eocene-Pliocene contact occurs on the sides of the canyons cut into the Mesa. Mission valley is shown at the left. The Mesozoic Blackmountain Volcanics occur in the foothills in the center left background beyond which are the mountains of the Peninsula Range. (*Spence Air Photo, March, 1931.*)

stones, siltstones and shale. The highest readily recognized terrace, which Ellis[1] has called the Poway Mesa, was developed on the pre-Tertiary metamorphic and igneous rocks lying to the east of the area under immediate consideration. This terrace appears to be genetically related to the old land surface of probable Pliocene age which extends far eastward into the mountains of the Peninsula Range.

The terraces, as at present preserved, represent primarily the work of marine erosion, only a small part of the outer portions of some of them being wave-built structures. The most extensive of these wave-cut terraces forms the surface of the Linda Vista Mesa north of the San Diego River, and of the San Diego Mesa and the Otay Mesa further south. Although these terraces appear to the eye to be entirely horizontal, they have been warped slightly since their formation, and are in general higher and have greater intervals between them in the southern part of the region. This rise continues to and beyond the Mexican boundary. Beginning with the highest, the elevations of the terraces above mean sea level are approximately as follows:

Poway Mesa	900 to 1200 feet
Otay Terrace	430 to 525 feet
Sub-Otay Terrace	about 425 feet
Avondale Terrace	200 to 250 feet
Chula Vista Terrace	100 to 130 feet
Tia Juana Terrace	50 to 200 feet
Modern Coastal Flats	0 to 20 feet

The Poway Mesa may have been developed in Pliocene time. It is now maturely dissected and has been completely eroded away over much of its probable former extent. The Otay Terrace is youthfully dissected by modern streams and it, as well as the lower terraces, was probably formed in Pleistocene time. However, marine fossils have only been found on the lower terraces, so that paleontologic proof of the age of the higher ones is lacking.

Several large intermittent streams heading in the Peninsula Mountains east of San Diego have carved steep-sided but flat-bottomed valleys through the mesa land; but valley bottoms and flood plains form only a small part of the total area. Most of the remainder of the land area consists of coastal lowlands, sandy beaches, sand spits and delta flats, such as Mission Beach, the Silver Strand south of the City of Coronado, and the low, partly marshy deltaic land between San Diego Bay and Mission Bay.

IGNEOUS ROCKS

The oldest rocks in this area are the Black Mountain volcanics, a series of intrusive and effusive, generally dark, basic igneous rocks associated with metamorphosed sediments. They occur in the foothills east of the mesa lands. No fossils have been found in them but they resemble in several respects rocks in the Santa Ana Mountains further north from which a few poorly preserved fossils of Triassic age have been obtained; consequently they are referred to the early Mesozoic. At Sweetwater Dam these pyroclastics appear to be largely basaltic breccias. However, albitite, altered andesitic tuffs, and augite

[1] Ellis, A. J., and Lee, C. E., U. S. Geol. Survey., Water Supply Paper 446, pp. 27-29, 1919.

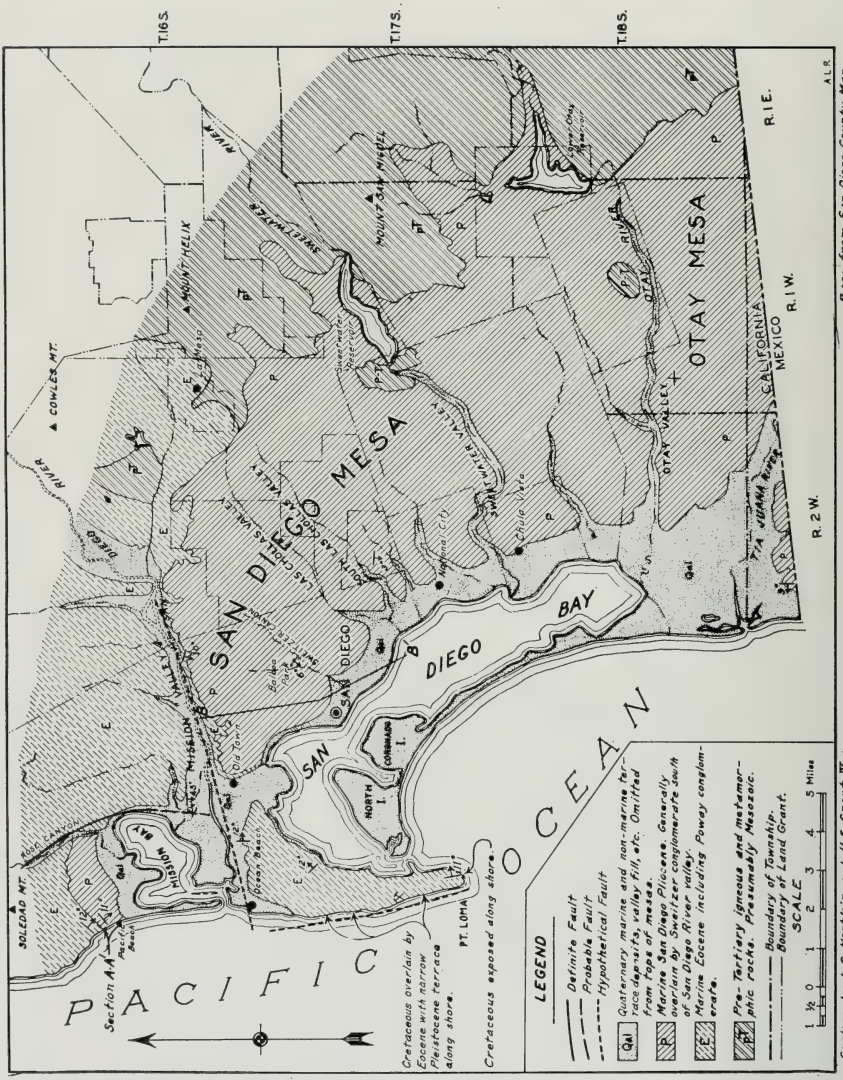

FIG. 2. Map showing the areal geology of a part of southwestern San Diego County, California.

andesites are present nearby, and in the eastern part of the La Jolla quadrangle Marcus Hanna [2] reported quartzite and fissile shales belonging to this same series of meta-igneous and meta-sedimentary rocks. This series formed the terrain upon which the Tertiary and presumably the Cretaceous sedimentary rocks were deposited.

The Black Mountain volcanics and meta-sediments have been intruded by acidic plutonic rocks such as quartz diorite and biotite granite which probably represent the margin of the Peninsula Range batholith. Thus they may be of the same age as the Sierran batholiths; at any rate they are probably Mesozoic, possibly late Jurassic.

On the east shore of Point Loma near the southern end of the Point a dike of igneous rock cutting the sedimentary beds is said[3] to be exposed at low tide. Although we have not seen this dike we believe the sedimentary rocks cut by the intrusion are of Cretaceous age. About a quarter of a mile north of the pier of the Scripps Institution of Oceanography, and 2¼ miles north of La Jolla, a basaltic dike from two to thirty feet thick cuts the Eocene Rose Canyon shale. It is exposed along the beach but does not extend to the top of the high bluff. It is the only igneous intrusion in the Eocene of which we are aware in this region. It has been described by Fairbanks[4] and by Marcus Hanna.[5] The only indication in this region of igneous activity during Eocene time is the rare occurrence of ash beds in the Poway conglomerate.

In the Pliocene San Diego formation bentonite beds interbedded with the marine sands attest contemporaneous volcanic activity. On both the north and south slopes of Otay Valley a few miles from its mouth beds of bentonite are worked for Fuller's Earth. The bentonite bed on the south side of the valley appeared to us to be approximately horizontal and seven or eight feet in maximum thickness.[6] On the north side of Otay Valley, at S. H. Perlmutter's ranch, several bentonite layers have been worked sporadically. This bentonite has been mineralogically determined as montmorillonite. A few miles north of these Otay exposures, on Federal Avenue just east of Thirty-fifth Street in San Diego, a nine-inch bed of bentonite occurs in the San Diego formation. Its relation to the Otay beds was not determined by the authors. Both these occurrences may represent the same or nearly the same horizon as the Pliocene ash beds just south of Tijuana, Mexico. About forty miles south of Tijuana on the road to Ensenada thick flows of basic lava are well exposed on the sides of the valley near the ruins of the Old Mission San Miguel. We believe these flows to be late Pliocene; they may represent the period of vulcanism that produced the bentonite beds in the San Diego formation.

STRATIGRAPHY

The sequence of sedimentary formations, their thicknesses, and the chief characteristics of their lithology are shown in the geologic

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[2] Hanna, M. A. Geology of the La Jolla Quadrangle: Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 16, No. 7, pp. 199-204, 1926.

[3] Blake, W. P., U. S. Pacific R. R. Reports, vol. 5, pt. 2, p. 176, 1856.

[4] Fairbanks, H. W., Eleventh Annual Rept. Calif. State Mineralogist, pp. 96-97, 1893.

[5] Hanna, M. A., *op. cit.*, p. 224, 1926.

[6] Local reports give it a maximum thickness of 25 feet, and it is said to underlie a thousand acres of land.

column (fig. 4). The estimates of maximum thicknesses of the exposed Tertiary sediments do not aggregate quite 3,000 feet. If the estimated 500 feet of Cretaceous sandstones and shales and the intermittent thin veneer of Pleistocene sands are added, the total unmetamorphosed sedimentary column does not exceed 4,000 feet. These sediments were all deposited in comparatively shallow water. The relatively thin sedimentary cover on the basement rocks may account for the slight local deformation of the Tertiary rocks by late Cenozoic orogeny. This contrasts sharply with the very thick Tertiary wedges in some of the basins north of San Diego, such as the Ventura basin, which have been

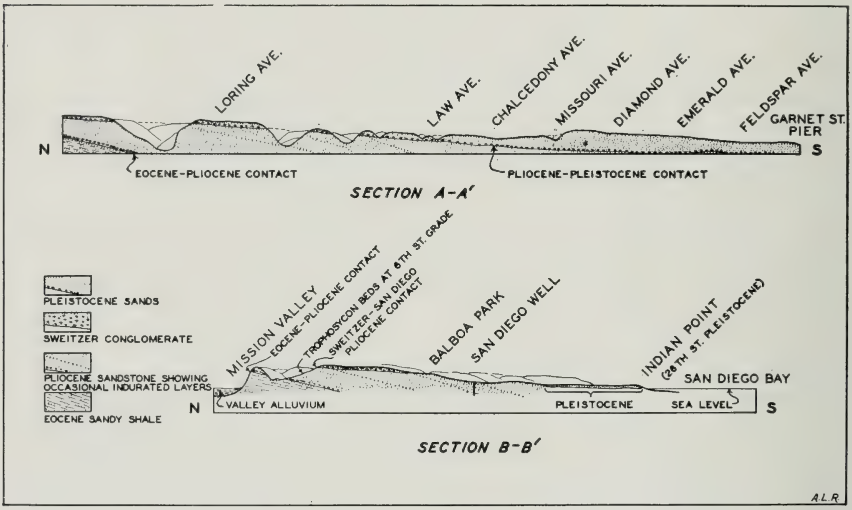

FIG. 3. Section A-A′. Generalized section of Pacific Beach Pliocene deposits as exposed in the bluff back of the beach. Total distance north to south about 3850 feet. Vertical scale greatly exaggerated.

Beds exposed in the lower half of the Pliocene section are those in which *Pecten healyi* occurs most abundantly. Beds exposed in the upper half of the Pliocene section contain abundant specimens of *Pecten bellus.*

Section B-B′. Diagrammatic sketch showing the relationships of the Pliocene San Diego formation to the Eocene, the Sweitzer formation on Sixth Street, and to the Pleistocene. Section approximately north and south from Mission Grade to foot of 26th Street. Distance about 5 miles. Vertical scale greatly exaggerated.

The locations of the cross-sections are shown on the map in text figure 2.

prominently folded and overthrust during the mid-Pleistocene Pasadenan orogeny. Other differences are the entire lack of marine Oligocene and Miocene beds and unusually meager record of Tertiary vulcanism in the San Diego region.

CRETACEOUS

Cretaceous sedimentary rocks are exposed only imperfectly in narrow zones along the shore of Point Loma and in the La Jolla region, and were nowhere observed to rest on older rocks. Their total stratigraphic thickness is unknown. The estimate of 500 feet is based on general field observations; detailed study may increase this figure considerably. The Cretaceous sediments are believed to rest on an irregular erosion surface developed on the Black Mountain volcanics,

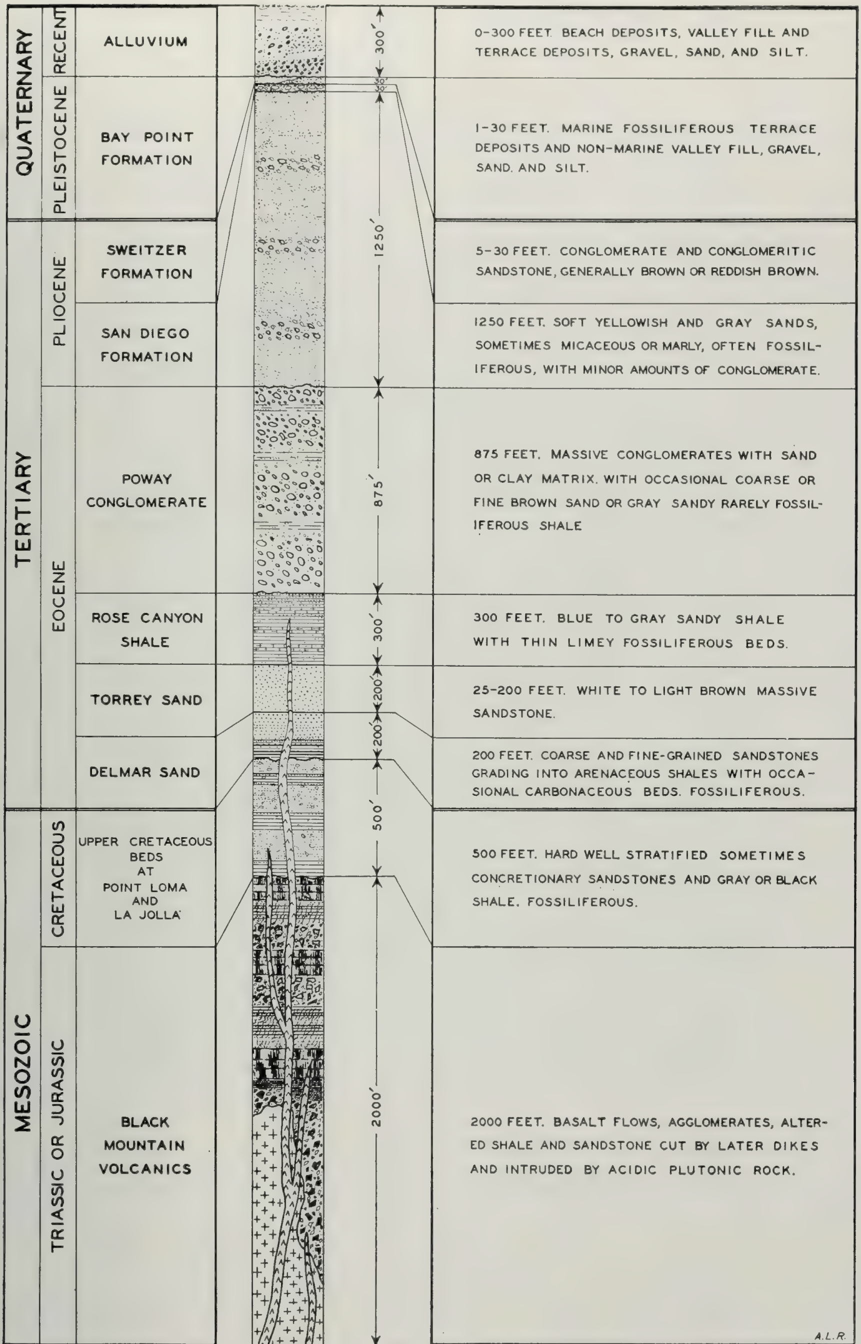

FIG. 4. Columnar section of the rocks exposed in the southwestern part of San Diego County, California. This section is compiled from observations of surface exposures of the rocks.

but overlapping later formations conceal their relationships to the basement rock.

The Cretaceous rocks consist mostly of massive to well-bedded brownish to gray, well-cemented sandstones and fine-bedded dark shales which are in part highly carbonaceous. Near La Jolla the sandstone is irregularly indurated and somewhat concretionary, producing irregular erosional remnants. At the south end of Point Loma in

FIG. 5. Cretaceous concretionary sandstone at La Jolla Caves. (*Photo, 1937.*)

the lower part of the cliff east of the Lighthouse the authors collected a specimen of *Baculites* and a conifer of ancient type from a thin-bedded bluish-gray shale. Other collectors[7] have obtained several Cretaceous species from Point Loma, including *Nemodon vancouverensis* Meek, *Coralliochama orcutti* White, *Crassatellites lomana* Cooper, *Baculites fairbanksi* Anderson, *Hamites vancouverensis* Meek, *Heteroceras cooperii* Gabb, *Parapachydiscus, catarinae* Hanna & Anderson,

[7] Cooper, J. G. Calif. State Mining Bur., Bull. 4, pt. 5, pp. 60-63, 1894.
Anderson, F. M. Proc. Calif. Acad. Sci., Ser. 3, Geology, vol. 2, no. 1, pp. 27-32, 1902.

and several other species. These species indicate a Campanian, upper Senonian, upper Cretaceous age.

EOCENE

La Jolla Formation

Marcus Hanna has given a detailed account of the Eocene formations exposed in the La Jolla quadrangle to which the reader is referred[8] for more data than can be included here. Hanna subdivided the Eocene into the La Jolla formation below and the Tejon formation above. The La Jolla formation, of middle Eocene age, he subdivided into Delmar sand (100 feet), Torrey sand (20 to 200 feet) and Rose Canyon shale (300 feet). The lower two members (the Delmar and Torrey sands) have not been positively recognized in the San Diego Quadrangle, although sufficient field work has not been done on Point Loma to be certain that they are not present there. Except on Point Loma and in a small area west and northwest of La Mesa, no Eocene is exposed anywhere in the region south of the south edge of Mission Valley. That Eocene beds underlie the Pliocene in part, if not most, of the southern area is proved by the occurrence of diagnostic Eocene fossils recovered from wells drilled in the southern part of the San Diego area. The San Diego Gas and Petroleum Corporation Holderness No. 1 Well in the southeast quarter of Sec. 32, T. 18 S., R. 2 W., S. B., near the mouth of the Tia Juana River,[9] penetrated over a thousand feet of Eocene shales, sandstones and conglomerates. According to George H. Doane *Discocyclina clarki* Cushman was encountered in cores of this well between 2946 and 2959 feet and also between 3286 and 3289 feet. In cores from depths between 3289 and 3324 feet *Turritella applini* M. Hanna, *Corbula cliffensis* M. Hanna, *Acila decisa* Conrad and several other species were obtained which indicate the presence of the Rose Canyon member of the La Jolla formation.

The lowest member of the La Jolla formation, the Delmar sand, consists of greenish, gray, or reddish sandstone or sandy shale, often cross-bedded or lenticular, with poorly preserved marine fossils locally in the lower portion, and sporadic layers of fossil leaves in the upper portion. The maximum exposed thickness appears to be about 100 feet, but its base has not been seen. M. Hanna collected 32 species of Eocene fossils from the Delmar member of which the most common, *Ostrea idriaensis* Gabb, *Potamides carbonicola* Cooper and *Unio* (?) *torreyensis* M. Hanna, suggest a fairly warm, shallow brackish-water embayment. Of these 32 species, 5 have been identified from the "Domengine" sandstone at the San Joaquin Coal Mine west of Coalinga by H. E. Vokes.[10] Analogous conditions may have prevailed at both these localities at substantially the same time, that is, Capay time.

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[8] Hanna, M. A., *op. cit.*, pp. 187-246, pls. 17-23, map.

For a description of the Eocene fossils see: Hanna, M. A., An Eocene invertebrate fauna from the La Jolla quadrangle, California: Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 16, no. 8, pp. 247-398, pls. 24-57, 1927. *See also* Cushman, J. A., and Hanna, M. A. Foraminifera from the Eocene near San Diego, California: Trans. San Diego Soc. Nat. Hist., vol. 5, no. 4, pp. 45-64, pls. 4-6, 1927.

[9] In official Mexican usage this name is spelled Tijuana. The American usage is Tia Juana.

[10] Vokes, H. E. Ann. New York Acad. Sci., vol. 38, 246 pp., 22 pls., 1939; *see* pp. 24-26.

The Torrey sand member of the La Jolla formation rests on the Delmar member with gradational contact. In the eastern part of the La Jolla quadrangle the Torrey rests unconformably on the Black Mountain volcanics.

A maximum thickness of about 200 feet is exposed. It consists essentially of white to light-gray or brown, massive, rather clean sand. Its coarse grain, cross-bedding, occasional slightly reddish color and almost complete lack of marine fossils suggest that it is largely non-marine in origin. At or near its type locality (Torrey Pines) occasional limonitized marine pelecypod outlines and a thin intercalated marine shale suggest a fluctuation of conditions. It may represent conditions somewhat analogous to those that prevailed while part of the Ione of the San Joaquin Valley was being laid down. Its stratigraphic position below the Rose Canyon shale suggests that it may be

Fig. 6. Characteristic exposure of Rose Canyon shale member of the La Jolla formation on the east side of Rose Canyon about one mile above its mouth. These Eocene beds are approximately horizontal except those at extreme right near Santa Fe Railway bridge which have a steep northerly dip. (*Photo, March, 1939.*)

of late Capay or early Domengine age. It is well exposed, forming castellated erosional remnants high upon the hillsides near the mouth of Soledad Canyon south of Del Mar.

The Rose Canyon shale, the uppermost member of the La Jolla formation, attains a thickness of at least 300 feet and is the most widely distributed member in the San Diego region. It rests conformably on the Torrey sand or overlaps the sand and rests unconformably on the Black Mountain volcanics or the Cretaceous sandstones. As already mentioned, the Rose Canyon shale has been recognized in a well drilled near the mouth of the Tia Juana River, and it may be widely present beneath the San Diego formation, although the San Diego overlaps it to the east. The Rose Canyon member consists mostly of gray or brownish shale and silty mudstones with minor amounts of conglomer-

ate and a few beds of limestone up to a foot in thickness. In general, the argillaceous and silty beds are poorly stratified. Marcus Hanna listed 146 species from the Rose Canyon shale, and later collectors, notably Frank B. Tolman, have obtained several additional forms. The following species are listed here as characteristic or representative of this uppermost member of the La Jolla formation: *Acila decisa* Conrad, "*Crassatellites*" *semidentata* Cooper, *Glycymeris rosecanyonensis* M. Hanna, *Macoma rosea* M. Hanna, *Nuculana parkei* Anderson and Hanna, *Calyptraea diegoana* Conrad, *Ectinochilus problematica* M. Hanna, *Ectinochilus canalifer supraplicatus* Gabb, *Pelecyora aequilateralis* Gabb, "*Surcula*" *lindavistaensis* M. Hanna, "*Surcula*" *praeattenuata* Gabb, *Turritella applini* M. Hanna, *Turritella scrippsensis* M. Hanna, *Turritella soledadensis* M. Hanna, *Aturia myrli* M. Hanna, *Eutrephoceras hannai* Vokes, "*Flabellum*" *sandiegoensis* M. Hanna, *Discocyclina clarki* Cushman, *Discocyclina cloptoni* Vaughan and a *Discocyclina* similar to if not identical to *Discocyclina psila* Woodding. This fauna is of approximately Domengine age.

Poway Formation

The Poway conglomerate overlies the La Jolla formation. In some places the beds are conformable, at other places an erosional unconformity separates the two formations. Marcus Hanna placed the conglomerate in the Tejon formation. As this latter name applies to a lithologic or cartographic unit with a type locality in a distant and entirely distinct basin, we do not recommend its use in the San Diego region. Furthermore, the type Tejon is largely marine, whereas the Poway appears to be mostly non-marine. If a "standard" cartographic unit must be used for the Poway conglomerate,* Sespe formation would seem to us to be more appropriate than Tejon. In the present paper we shall refer to it as the Poway formation.

The Poway attains a thickness of at least 875 feet. It is rather widely distributed in the eastern and southern portions of the La Jolla quadrangle and forms the terrain upon which the now maturely dissected Poway Mesa was developed in the general region between El Cajon and Poway valleys. M. Hanna [11] described the lithology of the Poway formation as follows: "*Lithology.*—The Poway conglomerate is composed of conglomerates, sands, shales, and rather extensive areas of caliche. Of these, the conglomerates make up the greater part. The boulders of the conglomerate are usually well rounded, and range in size up to three feet or more. The average size is probably three to six inches. These boulders are of many types of rock, although andesitic boulders are by far the most abundant. The matrix is usually quite hard. It is light gray in color when fresh, but on

* Attention should be called to the fact that the Ballena placer, located east of Ramona in T. 13 S., R. 2 E., S. B., and described by F. J. H. Merrill on p. 652 of the State Mineralogist's Report XIV, is correlated as part of the Poway conglomerate by Maurice Donnelly in the State Mineralogist's Report XXX, p. 369. The similarity of conditions of deposition of the Poway with that of the Ione formation (including the gold-bearing channels of the Sierra Nevada), both of which apparently are very nearly the same age, is certainly noteworthy. (*Comment by Olaf P. Jenkins.*)

[11] Hanna, M. A. An Eocene invertebrate fauna from the La Jolla quadrangle, California: Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 16, no. 8, pp. 247-398, 1927; *see* pp. 213-214.

A. N. Dusenbury Jr. has discussed the occurrence of foraminifera from the Poway conglomerate: Micro. Paleo. Bull., vol. 3, no. 3, pp. 84-95, 2 figs., June 15, 1932.

weathering becomes brown. Cross-bedded sands are interstratified with the conglomerates. . . . In places the sand grades into shale. Gray shale lenses are found especially through the lower 200-300 feet in the southern part of the quadrangle. These sands and shales are fossiliferous. The upper Poway conglomerate is often of soft, white, chalky caliche. This 'marl formation' as it is locally called, contains a large percentage of calcium carbonate. Such a high percentage, in fact, that it was burned for the lime which was used in the old dam above the San Diego River gorge. This caliche varies considerably in thickness. Near the center of the area it becomes more sandy. It occurs intermittently from the north to the south side of the quadrangle."

Although most of the Poway formation is unfossiliferous and is in part of non-marine origin, local beds or lenses of fine sandstone and shale contain marine Eocene invertebrates, some of which are known to occur in the type Tejon. M. A. Hanna lists the following mollusks from the Poway conglomerates: *Acila lajollaensis* M. A. Hanna, *Brachydontes ornatus* Gabb, *Crassatellites mulates* M. A. Hanna, *Leda parkei* Anderson & Hanna, *Pholadomya murrayensis* M. A. Hanna, *Pteria* cf. *pellucida* Gabb, *Tellina tehachapi* Anderson & Hanna, *Calyptraea excentrica* Gabb, *Discohelix murrayensis* M. A. Hanna, *Ficopsis remondii* Gabb, *Ficus mammillatus* Gabb, *Turritella applini* M. A. Hanna, *Pseudoliva volutaeformis* Gabb.

Within the last few years several specimens of fossil vertebrates have been collected in the Poway formation of this region. Professor Chester Stock, who examined these fossils, identified a carnivore (presumably a creodont), an agriochoerid, a small insectivore, and a titanothere probably belonging to the upper Eocene genus *Metarhinus*. According to Professor Stock, these vertebrates suggest an upper Eocene age and a faunal stage earlier in time than the upper Eocene part of the Sespe formation in the Ventura basin.

PLIOCENE

San Diego Formation

The Pliocene San Diego formation rests with a local angular unconformity upon the Rose Canyon shale member of the La Jolla formation, or on the Poway formation or it overlaps them to rest with marked unconformity upon the Black Mountain volcanics. Its most northern known occurrences in this region are on the south slope of Soledad Mountain and along the shore at Pacific Beach. The most extensive area of the San Diego formation is in the youthfully dissected mesa lands south of Mission Valley to and beyond the International Boundary. We have not recognized any Pliocene beds on Point Loma. The areal distribution is shown on the geologic map (fig. 2).

One of the best known exposures of the San Diego Pliocene is in the beach bluffs at Pacific Beach about eight or nine miles northwest of the business center of San Diego. Here the yellowish and bluish-gray Pliocene sandstone rests with slight angular discordance on the fine-gray and brownish shaley sandstone of the Eocene. A bed of conglomerate about three feet thick occurs at the base of the Pliocene.

This contact dips below the beach sands about 1,740 feet north of the projected west end of Law Street. Northward the contact is truncated by the Pleistocene terrace deposits. Both the Eocene and the Pliocene at the contact dip about 11° or 12° southward, and apparently strike N. 40° to 60° E. Southward in the bluff the Pliocene flattens but finally dips below the beach about 1,200 feet south of the west end of Law Street. The exposed thickness of the Pliocene here is about 380 feet. It consists of brownish- to bluish-gray, massive to moderately well-bedded sandstone, with layers of indurated calcareous beds and numerous fossils. In the massive yellowish and gray sandstone overlying the basal conglomerate are numerous specimens of *Pecten (Patinopecten) healeyi* Dall while just a short interval above, *Pecten stearnsii* Dall and *Pecten bellus* Conrad are abundant. In higher beds

FIG. 7. The Eocene-Pliocene-Pleistocene contacts in the bluff at the north end of Pacific Beach. The Pliocene sandstone of the San Diego formation is coarser grained, more pebbly and thicker bedded than the underlying Eocene. Contacts emphasized by black lines. (*Photo, March, 1939.*)

numerous other species occur, such as *Arca trilineata* Conrad, *Pecten subdolus* Hertlein, *Pecten cerrosensis* Gabb, *Opalia anomala* Stearns and *Opalia varicostata* Stearns.

On the south slope of Soledad Mountain the San Diego formation is represented by soft, fine, brownish sandstone dipping south. These beds contain a small fauna including beautifully preserved specimens of *Pecten healeyi, Pecten stearnsii* and *Pecten (Swiftopecten) parmeleei.* The Pacific Beach-Soledad Mountain Pliocene beds are not continuous in surface exposure with the San Diego formation in the San Diego Mesa region, and differences in fauna may indicate that some of the lower beds in the Mesa are not represented at Pacific Beach. On the other hand, the slight differences might well be due to differences in ecology.

On the steep south slopes of Mission Valley east of Old Town the San Diego formation rests upon the La Jolla formation. Along the Sixth Avenue grade near Mercy Hospital the Pliocene beds are a fine-grained light-gray marly sandstone containing rare casts of a *Trophosycon*. The Pliocene beds near here dip about 10° southward, but in Balboa Park the San Diego formation has less dip, and throughout the mesa lands south to the Mexican boundary, gentle dips of five or six degrees, mostly south or southwest, are common. At some places, such as in the Otay Mesa region, the beds are approximately horizontal. South of the Tia Juana River, however, the San Diego formation exposed in the sides of the mesa which extends into Mexico has a dip of about nine degrees west.

Lithologically, the San Diego formation in the mesa lands south of Mission Valley consists almost entirely of light-brown, buff or bluish-gray fine sandstone with occasional pebble lenses or layers. Near the Mexican boundary west of Tijuana, a heavy bed of conglomerate over 100 feet thick occurs. Some of the sandstone is decidedly marly and in the upper part of the section bluish-gray soft micaceous sands are often present. The mica appears to be largely brown biotite. In these beds as well as in others, grains of green hornblende are rather abundant in the heavy mineral group.

Although clay and shale are very rare in the San Diego formation, bentonite is interbedded in the Pliocene fine-grained sandstone on both sides of Otay Valley and in Las Choyas Valley on Federal Avenue. These bentonite deposits have been mentioned on a preceding page under the discussion of the igneous rocks.

From a study of outcrops and well logs the San Diego formation appears to attain a maximum thickness in the region southeast of San Diego of approximately 1,250 feet. The beds thin progressively eastward where they overlap the Black Mountain volcanics.

Evidence of the Pliocene age of the San Diego formation is provided by distinctive Pliocene mega-fossils which occur at several localities in the mesa lands as well as at Pacific Beach and on the south slope of Soledad Mountain. Along India Street in the city of San Diego, *Pecten healeyi* and *Pecten stearnsii* are common, and in Balboa Park a medium-sized fauna including a number of extinct species has been obtained. An extinct *Dosinia* is locally abundant near the Laurel Street bridge and the scutellid echinoid *Merriamaster pacificus* Kew has been obtained in Cabrillo Canyon. The old San Diego Well, now filled in, is located in Cabrillo Canyon, Balboa Park, on the northerly prolongation of the east line of Eleventh Avenue, 85 feet north from the easterly production of the north line of Beech Street. A number of species of mollusks were obtained from this well by Henry Hemphill and identified by Dall.[12]

Among the 69 species listed by Dall are *Arca* (*Anadara*) *trilineata*, *Pecten healeyi*, *Pecten stearnsii*, and a species which is probably *Gyrineum lewisii* Carson. These are definite indicators of a Pliocene age. At a few localities in the mesas southeast of Balboa Park diagnostic Pliocene fossils have been obtained, and in David Smallcomb's Well just north of the Mexican boundary and west of Tijuana,

[12] Dall, W. H. Proc. Calif. Acad. Sci., vol. 5, pp. 296-299, 1874. This was the first faunal assemblage of any size in California to be definitely placed in the Pliocene. The San Diego Well is the type locality of the San Diego Formation.

Mexico, *Pecten healeyi* is abundant. In addition to marine invertebrates two species of extinct birds have been obtained from the San Diego formation southeasterly from Balboa Park.

Sweitzer Formation

Unconformably overlying the San Diego formation and capping most of the tops of the mesas south of Mission Valley is a stratum of brown and brownish-red conglomerate or pebbly sandstone which has been named the Sweitzer formation.[13] At some localities this formation continues over the edges of the Otay Terrace (mesa top) to the lower terraces. The maximum thickness of this formation is about 20 feet. As no fossils have been obtained in it, its age can only be definitely stated as post-San Diego. It may be of late Pliocene or early Pleistocene age. Its origin has been briefly discussed by the authors in their larger paper on the San Diego formation.

PLEISTOCENE

Bay Point Formation

Resting upon a low terrace at several places near the shore of Mission Bay and forming the uppermost few feet of the beach bluff at

FIG. 8. Crossbedded marine Pleistocene sands of the Bay point formation at the type locality on the west side of Bay Point, San Diego, California. (*Photo, 1937.*)

Pacific Beach is a deposit of sand and gravel containing abundant marine fossils of late Pleistocene age. Generally the fossils are more abundant or concentrated in the lower part, and some of the upper, generally less pebbly beds, may be non-marine. The authors have

[13] Hertlein, L. G., Stanford Univ. Bull., 5th Ser., no. 78, vol. 4, p. 82, 1929.

assigned the name *Bay Point formation* from its exposures along the west shore of Bay Point in Mission Bay. At this locality light gray cross-bedded sands contain abundant specimens of *Dendraster* and *Donax laevigata.* At Pacific Beach the Bay Point formation has a larger fauna. At some localities this Pleistocene fauna includes the warm water species *Chione gnidia, Dosina ponderosa,* and *Amiantis callosa.* At the foot of Twenty-sixth Street in San Diego, at Spanish Bight, North Island, and at several other places, this formation is exposed on a low terrace. The faunas vary somewhat due to differences in ecology, but all together suggest a warm water late Pleistocene horizon, which may be equivalent to some part of the Palos Verdes formation (upper San Pedro of R. Arnold) in the Los Angeles region.

This formation is generally only five to ten feet thick but its maximum thickness may be 20 feet or more.

Some of the non-fossiliferous terrace cover and the deeper valley fill may be of Pleistocene age. Recent alluvium is present in most of the larger valley bottoms, in the delta flats and bay flats, and it is represented along the ocean shore by various beach deposits.

STRUCTURE

The Cretaceous and Tertiary rocks in the San Diego region have been but little folded. This lack of folding may be due in part to the thinness of incompetent sediments overlying the rigid Black Mountain volcanics and the crystalline rocks which have been intruded into them. Elsewhere in California such as in the Ventura and in the San Joaquin basins, the Tertiary sedimentary rocks attained local thicknesses of over five miles before being deformed by the mid-Pleistocene orogeny; here the total known thickness of all the sedimentary rocks resting on the Black Mountain volcanics is less than one mile.

The only major fold in the post-Black Mountain strata is in the Soledad Mountain mass. This is an asymmetrical anticline with an axis trending northwest a little less than a quarter of a mile north of the summit of Soledad Mountain. Erosion of this anticline has exposed Cretaceous rocks on the north slopes of the mountain. The northern limb of the Soledad anticline is nearly vertical, but the south limb has comparatively gentle dips to the southwest. The fold plunges steeply southeast and is intersected by Rose Canyon between Ladrillo and the mouth of San Clemente Canyon. It is not seen in canyons cut into the Linda Vista Mesa farther southeast. The possible relation of this anticline to the Rose Canyon fault has not been investigated by the authors, but they believe the folding preceded the faulting.

The Mission Bay area has been considered synclinal. Although the Eocene and Pliocene beds on the south slope of Soledad Mountain dip southward, the Eocene on the north end of Point Loma dips east, and no Pliocene rocks are known there. If a syncline is present with an east-west axis, the south limb is faulted down. It seems more likely that an east-west fault has dropped the beds down on the north with respect to the Point Loma beds on the south. If such a fault exists, it underlies and is obscured by deltaic and bay deposits, and passes up Mission Valley, gradually dying out to the east.

The Eocene rocks throughout the Linda Vista mesa have a gentle regional easterly dip. Slight irregularities in dip do not seem to indicate any other continuous structure. The low but conspicuous ridges on the western part of the mesa are superficial depositional features, possibly beach ridges, as pointed out by Ellis.

Point Loma appears to be an eastward tilted block complicated in detail by some differential tilts as well as by numerous small faults. No significant folds or closures were seen here by the authors during their limited field work.

It is probable that a north-south fault just off the west shore of Point Loma has elevated the rocks to the east with respect to those on the west, but little evidence aside from the dip and the presence of some warm springs exposed at low tide is available to substantiate its existence. Even less evidence exists for a hypothetical north-south fault paralleling the east side of Point Loma. The numerous small faults exposed in the sea cliff below the Coal Mine terrace on the west side of Point Loma have small throws and are mostly normal.

A fault trending more or less northerly along Rose Canyon has already been mentioned; beds on opposite sides of Rose Canyon do not match. A southward extension of this fault along the east side of Mission Bay is suggested by the former presence of a warm spring and considerable tufa near the Santa Fe Railroad tracks between Morena and Atwood. Just north of the mouth of Mission Valley about one-half mile south of the mouth of Tecolote Valley a small hill of Rose Canyon shale formerly existed in which the beds had a dip of 45° S. This is different from the regional dip, and may indicate the presence of a fault. The Rose Canyon fault may continue southward beyond Old Town into San Diego Bay, but definite evidence is lacking. The San Diego Mesa ends abruptly at Old Town, but it might have been truncated by lateral erosion by the San Diego River when the river flowed into San Diego Bay.

The San Diego Pliocene beds in the area east and southeast of San Diego have either gentle south or southwest dips, generally less than 6°, or, at some localities in the mesa between Sweetwater Valley and Otay Valley, are approximately horizontal. No eastward dips of any consequence were detected during the field work and the eastward slope of the surface of Otay Mesa appears to be in large part due to greater erosion of the eastern surface where unprotected by the Sweitzer conglomerate. The steep irregular dips along the south margin of Otay Mesa near San Ysidro are due to landslides and do not represent orogenic folding.

The sandstones and conglomerate in the high mesa along the Mexican boundary west of Tijuana dip about 9° toward the west. This may be due in part to the deposition of these sediments as foreset beds in an ancient delta, but no doubt later tilting also occurred.

A geophysical survey made on the low delta land near the mouth of the Tia Juana River is said to have indicated that beds were rising in a southwesterly direction from the Holderness No. 1 Well which was located in the SE$\frac{1}{4}$ Sec. 32, T. 18 S., R. 2 W., S. B., but no structure is apparent in the surface features.

A few small normal faults—none more than a few feet in throw—were seen in bluffs and road cuts in the mesa region east of San Diego

Bay. The large fault indicated by Dusenbury [14] in the basement rocks just east of the Poway Terrace is based largely upon theoretical considerations and at any rate is far east of the Tertiary basin as considered in this report.

ECONOMIC GEOLOGY

The search for petroleum in the southwestern part of San Diego County has resulted in the drilling of a number of dry holes. The logs of many of these wells are too "standardized" to be of much value from a scientific standpoint, and it seems that in only a few cases ditch samples or cores were adequately studied geologically or paleontologically. None of these wells have produced petroleum. In a few cases "traces of oil" have been indicated in the logs.

As the Tertiary beds in the San Diego region are dominantly clastic, and closed structures are absent, it appears highly improbable that petroleum in commercial quantities will be discovered in Tertiary sediments here. While stratigraphic traps might exist in the overlapping beds, no source rock such as the thick organic shales in the basins further north have been discovered in southwestern San Diego County. If future wells are drilled in the hope of striking oil in paying quantities, an adequate geologic and paleontologic study of the well samples should be made so that scientific information will result from the otherwise probable futile expenditure of money.

WELLS DRILLED IN THE SAN DIEGO REGION

Nearly 50 dry holes have been drilled in San Diego County in search of oil. We have looked over the logs of many of these where they were available, but as most of the subsurface data consist of drillers' descriptions of lithology without any significant paleontologic facts, little of value was obtained. The Petroleum World, Annual Review, 1936, p. 162, gives a brief list of dry holes in San Diego County with their total depth, but no logs.

The following are of interest in presenting evidence in regard to the character and depth of sedimentary rocks in this region:

Borderland Exploration Company, Point Loma No. 1, Pueblo Lot 211, Sec. 30, T. 16 S., R. 3 W., S. B., San Diego, California. Drilled to a depth of 5101 feet. Abandoned 1932. (Log by courtesy of G. D. Hanna and C. C. Church.)

1,560 feet.	Core.	Hard gray sandy shale; plant fragments.
1,580 feet.	Core.	Hard gray sandy shale; plant fragments, foraminifera. Fragments of *Inoceramus* and ammonites.
1,680 feet.	Core.	Hard gray sandy shale; plant fragments and ammonite fragments.
1,787 feet.	Core.	Hard gray sandy shale; plant fragments.
1,885 feet.	Core.	Hard gray sandy shale; plant fragments.
1,945 feet.	Core.	Hard gray sandy shale; fragments of *Baculites chicoensis* Trask.
2,000 feet.	Core.	Gray, hard silty clay shale. Forams rare and small. *Textularia, Silicosigmolina, Marginulina.*
2,010 feet.	Core.	Hard gray sandy shale; plant fragments.
2,100 feet.	Core.	Coarse greenish pebbly sandstone.
2,250 feet.	Bit.	Gray fine to coarse sand and shale. No fossils. Forams in core appear to be Cretaceous but determination not certain.
2,500 feet.	Core.	Hard gray sandy shale; plant fragments, foraminifera and a large piece of an ammonite.
2,771 feet.	Core.	Hard reddish brown sandstone with pebbles marked "top of red beds."

[14] Dusenbury, Jr., A. N. A faunule from the Poway conglomerate, upper middle Eocene of San Digeo County, California: Micropaleo. Bull., vol. 3, no. 3, pp. 84-95, June 15, 1932, Stanford University, Calif. See text figure on p. 90, also text p. 92.

3,110 feet. Core. Hard red sandstone.

3,670 feet. Core. Hard red conglomerate; pebbles up to 3 inches. All samples with fossils are Cretaceous. The red beds are of uncertain age; nothing similar to this in West Coast Cretaceous, so may be older.

3,735 feet. Core. Hard greenish-gray altered rock, probably metamorphosed rhyolite or similar form. In thin flakes under the microscope the substance is seen to be translucent. It contains no sand or quartz and does not belong to the granite series. Pyrite and calcite are found in seams and the rock itself contains some mineral which reacts like dolomite in hot acid, although the proportion is small.

3,828 feet. Core. Greenish gray, partially crystalline, limy, altered rock with veinlets.

3,857-58 feet. Core. Brown loose fine sand—no fossils. The brown sand of the last sample is so loose as to seem out of place with the dense limey rock a few feet above it. No fossils were noted to indicate the possible age of the material.

4,290 feet. Core. Light gray, hard, fine grained crystalline rock with seams of calcite.
This confirms the determination made higher in the well that the formation is non-sedimentary.

Borderland Exploration Co., Point Loma No. 2, Pueblo Lot 258, 300 feet northerly, 175 feet easterly from the southwesterly corner on the northeasterly quarter of Pueblo Lot 258. Started November 13, 1931, abandoned March 1933. Drilled to 2610 feet, ''gray shale'' at bottom.

Choate and Overbaugh, Encanto Well, Tract 11, San Diego, California, 1925. Driller's log from surface to 1235 feet where it was reported to end in sandstone and limestone.

National City Oil Co., Well No. 1. Sec. 22, T. 18 S., R. 2 W., S. B., 1933. Driller's log from surface to 2625 feet. Last hundred feet reported as ''Red rock, cave. Shale-brown, sand-fine. Lime, showing oil.''

Paradise Oil Co., Well No. 1, Rancho de la Nacion. Elevation 290 feet, April 1, 1927. Penetrated 2130 feet of sediments, and at that depth hard limestone and sandstone were logged.

Community Oil Well Co., Scott Well No. 5. Lot 1194, T. 16 S., R. 3 W., S. B., 1919. At 1274 feet depth, shale and sandstone were logged.

Itasca Petroleum Company, Otay Mesa No. 1. Sec. 33, T. 18 S., R. 2 W., S. B., San Diego County, California. Drilled with rotary tools. (Log by courtesy of G. D. Hanna and C. C. Church.)

Operators logged about four beds of ''Oolite'' or ''Fuller's Earth'' from the surface to about 400 feet. Each stratum was said to be about 50 to 60 feet thick. General Petroleum Co. clay excavations are very near this well location.

1,100 feet. Core. Gray friable, unassorted pebbly sand, silt and clay. No fossils.

1,150 feet. Core. Gray unassorted sand, silt and shale, quite soft. Appears to be of continental or non-marine deposition.

1,560 feet. Core. Gray hard amorphous rock without bedded structure. Fragments of other rocks or sand are not easily seen until a section of the rock is polished. The rock is a metamorphosed sandstone or conglomerate and not igneous as it at first appears.

San Diego Gas and Petroleum Corporation, Holderness No. 1 Well, [also known as Saratoga No. 1]. S.E. $\frac{1}{4}$ of Sec. 32, T. 18 S., R. 2 W., S. B., about 16 miles south of the city of San Diego and $1\frac{1}{2}$ miles north of the International Boundary. Elevation 20 feet. This is near the mouth of the Tia Juana river. Report by G. H. Doane on the cores obtained in drilling this well and permission to use the same granted through the courtesy of Mr. J. E. Pettijohn.

	Depth in feet	Thickness in feet
Alluvium	0- 300?	300
San Diego Formation	300-2,900?	2,600
La Jolla Formation		
Rose Canyon Shale	2,900-3,800	900
Delmar Sand	3,800-3,900	100
"Chico" Formation	3,900-5,260	1,360
Trabuco Formation	5,260-5,529	269
Black Mountain Formation	5,529-6,332	803 plus

According to Mr. F. B. Tolman the greatest depth at which Pliocene fossils were encountered in the Holderness Well was 1680 feet. If this latter depth represents the base of the Pliocene then the San Diego formation would have a thickness in this well of about 1380 feet.

Dr. G. D. Hanna and C. C. Church have furnished us a report on a core of this well from a depth of 3706 feet as follows:

3,706 feet. Core. Gray, sandy, micaceous shale with abundant carbonized plant remains, shell impressions and foraminifera: *Cibicides* sp., *Eponides mexicana* Cushman, *Robulus inornatus* d'Orbigny, *Robulus mexicanus* var. *nudicostatus* Cushman & Hanna, *Siphonina* cf. *jacksonensis* Cushman & Applin. Eocene. Domengine.

Ellis has given a number of logs of wells most of which were drilled for the purpose of securing water in the San Diego region. Some of these will be briefly mentioned here. The location of the wells are shown on Ellis's Plate II.

Beaver Oil Well. On Poway Mesa in upper part of San Clemente Canyon, about 12 to 13 miles east of the coast. Elevation about 975 feet above sea level. Drilled to a depth of 1,050 feet. Coarse gravels of the Poway conglomerate 875 feet in thickness and 175 feet of granitic rock with thin covering of marl.[15]

Pueblo Lot 146. Point Loma, San Diego County, California. Elevation 255.88 feet above high tide. Drilled to a depth of 400 feet. Completed March 18, 1901. Dark blue shale at 190 feet; coal bed one foot thick at 262 feet; dark blue shale at 298 feet; shale, gravel, and clay, at 400 feet.[16]

L. K. Lanier's Well. In south Las Chollas Valley, about 4 miles east of San Diego, California. Elevation about 175 feet above sea level. Drilled to a depth of 360 feet. Yellow sand with a few layers of clay 210 feet thick; very fine dark colored sand containing a large admixture of black mica 150 feet thick, and containing abundant Pliocene fossils.[17]

Robert Dick's Well. Just northwest of Hollywood, and west of Encanto, San Diego County, California. Elevation about 250 feet above sea level. Drilled to a depth of 203 feet. Forty feet of loam, and 163 feet of clay, gravel and conglomerate.[18]

Angelus Heights, southwest of Lemon Grove, San Diego County, California. Elevation about 400 feet above sea level. Drilled to a depth of 375 feet. Mostly clay, sand, gravel and conglomerate. At 375 feet sand yielding salty water.[19]

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[15] Ellis, *op. cit.*, p. 68.
[16] Ellis, *op. cit.*, p. 61.
[17] Ellis, *op. cit.*, p. 62.
[18] Ellis, *op. cit.*, p. 62.
[19] Ellis, *op. cit.*, p. 63.

Chula Vista Oil Co., Well No. 1. Northeast of Chula Vista, California, and south of Sweetwater River. Elevation about 150 feet above sea level. Drilled to a depth of 678 feet. Fifteen feet of conglomerate at a depth of 135 feet. The remainder mostly sand, shale, and clay.[19]

Chula Vista Oil Co., Well No. 2. A short distance south of Chula Vista No. 1. Elevation about 150 feet above sea level. Drilled to a depth of 582 feet. Fourteen feet of conglomerate at 130 feet. The remainder mostly sand, shale, and clay. A 2 foot bed of conglomerate at 582 feet.[20]

Chula Vista Oil Co., Well No. 3. Eastern part of Chula Vista, California. Elevation about 150 feet above sea level. Drilled to a depth of 660 feet, mostly sand, clay, and gravel, with minor mounts of conglomerate. Light yellow shale at 660 feet.[21]

Chula Vista Oil Co., Well No. 4. Just east of Chula Vista Oil Co. Well No. 3. Elevation about 135 feet above sea level. Drilled to a depth of 643 feet. Clay, sandstone and conglomerate. Twenty-four feet of conglomerate at 643 feet.[22]

Chula Vista Oil Well. Between Chula Vista Wells No. 2 and 4. Elevation about 150 feet above sea level. Drilled to a depth of 1,812 feet. Mostly clay and sand. Blue clay and sandy shale at 1,812 feet.[23]

Lo Tengo Oil Co. Well. On the west slope of Otay Mesa, about $1\frac{3}{4}$ miles north of the International Boundary and about $6\frac{1}{2}$ miles east of the coast. Elevation about 375 feet above sea level. Drilled to a depth of 3,400 feet. Two hundred forty feet of sandy clay and light yellow sand; 70 feet of conglomerate from 240 to 310 feet; yellow-blue, and brown sand, shale, clay with occasional conglomerates to 3,035 feet. Thirty-seven feet of sand and conglomerate at 1,487 feet; and 38 feet of conglomerate at 1,540 feet; 32 feet of conglomerate at 2,832; "soft sand, oil" at 2,985 feet; "hard, calcareous rock, streaks of sand in lower part" at 3,400 feet.[24]

Tia Juana Oil Well. Just north of the International Boundary and about $1\frac{1}{2}$ miles east of the coast. Elevation about 85 feet above sea level. Drilled to a depth of 1,405 feet. Penetrated 80 feet of conglomerate; 2 feet of water sand; 500 feet of quicksand with mica; thin coal seam at 582 feet; alternating shale and sand at 800 feet from which a specimen of "*Spicula*" [?*Spisula*] was brought to the surface; alternating shale and sand, "shale with trace of oil" at 804 feet; "shale with streaks of oil sand" at 1,008 feet; hard fossil bed at 1,350 feet; sandstone with water at 1,362 feet; "hard sand, trace of oil," "sands and black shales, showing oil" at 1,405 feet.[25]

ECONOMIC MINERAL PRODUCTS

Clay, fuller's earth and salt are the only mineral products at present known to be of any great value in the restricted region covered by this report. Farther east and north several other mineral products are of economic importance.

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[19] Ellis, *op. cit.*, p. 65.
[20] Ellis, *op. cit.*, p. 65.
[21] Ellis, *op. cit.*, p. 65.
[22] Ellis, *op. cit.*, p. 65.
[23] Ellis, *op. cit.*, p. 66.
[24] Ellis, *op. cit.*, p. 67.
[25] Ellis, *op. cit.*, p. 67.

Extensive deposits of pottery clay as well as brick and tile clay occur in the Eocene sediments, principally in the area between Carlsbad and Rose Canyon. Easy access to the Santa Fe Railroad and good highways adds to their value.

On the sides of Otay Valley from three to six miles east of Otay, beds of volcanic ash (bentonite) are interbedded with the marine sandstone of the San Diego formation. These beds attain a thickness of eight or nine feet or more and have been worked for their value in refining petroleum products as well as other ways. This bentonite is largely the mineral montmorillonite.

Coal has been mined sporadically at localities scattered from the west side of Point Loma to Rose Canyon and Delmar, but none of the deposits are now being worked, and it is unlikely that they will be of much value. The thin coal beds occur in the Cretaceous (Point Loma Coal Mine) and in the Eocene of Rose Canyon and probably in the Eocene at a few other localities.

Salt (NaCl) has been obtained in commercial quantities by solar evaporation and refinement of the waters at the south end of San Diego Bay for several years. Magnesium salts and bromine are obtained as by-products from the salt-works bittern waters. At the present time the salt ponds on San Diego Bay cover an area of approximately 1500 acres and the production of salt ranges from about 2500 to 3500 tons per year.

Sand and gravel are exploited principally in the Oceanside area, the Otay district and in Mission Valley.

Igneous rock used for rip-rap of sea walls, jetties, etc., was formerly obtained from a quarry just below Sweetwater Dam but no rock is quarried there at the present time. Gray granite is produced near Lakeside but that is northeast of the area considered in this report.

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of California Journal of Mines and Geology.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

THE PROSPECT FOR "MINOR METALS" AND NONMETALLIC MINERALS [1]

By John Wellington Finch *

Keen interest centers at present in a number of so-called minor metals and in the nonmetallic minerals. While the minor metals do not bulk as large in tonnage and value as copper, lead, zinc, iron, gold, and silver, nevertheless they are essential factors in our industrial economy. Recognizing this, the War Department includes several of the so-called "minor metals" on the list of strategic commodities and the Navy Department has acquired stocks for use in emergency. Some of the minor metals are of relatively recent importance and in a sense are modern metals associated with speed, reduced weight, and durability under adverse conditions. Their extending application in industry is a result of the better understanding of metals and alloys designed for specific purposes. A feature of their production is the higher price they bring in the market. Compare the prices of iron, copper, lead, and zinc for example, with those of aluminum, magnesium, molybdenum, tungsten, and vanadium. An added attraction for their producers is the excess of demand over domestic production. For many of these essential commodities American industry is dependent on foreign sources for a good share of its requirements. Study of the import figures reveals alarming deficiencies in the domestic supply of such basic raw materials as bauxite, manganese ore, chromite, tungsten ore or concentrates, vanadium concentrates, mercury, antimony, and a number of others. This fact is a challenge to American technical ability and ingenuity to devise means or processes that will supply the need from our domestic resources.

TABLE

IMPORTS FOR CONSUMPTION OF CERTAIN MINOR METAL RAW MATERIALS IN 1937

Commodity	*Quantity*	*Value*	*Principal source*
Ferroalloying:			
Chromite, long tons	553,916	$7,324,488	Africa, Cuba
Manganese ore, long tons	911,922	10,451,602	U. S. S. R., Gold Coast
Molybdenum (content), pounds	7,707	13,491	[1]
Tungsten ore and concentrates, pounds	10,189,625	2,940,038	China, British Malaya
Vanadium ore and concentrates, short tons	7,403	638,799	Peru
Light Weight:			
Bauxite, long tons	507,423	3,609,063	Surinam, British Guiana
Magnesium (powder), pounds	1,321	1,727	[1]
Miscellaneous:			
Antimony ore, short tons	42,453	1,775,011	Mexico, Chile
Metal, short tons	1,043	228,485	China, Mexico
Arsenic, white, short tons	19,256	820,864	Mexico, Sweden
Bismuth, pounds	67,225	54,007	[1]
Cadmium, pounds	828,535	1,075,330	Belgium, Canada
Cobalt (metal), pounds	1,073,129	1,341,928	Belgium, Finland
Mercury, Flasks	18,917	1,227,991	Italy, Spain

[1] Not available.

[1] Presented at meeting of American Mining Congress, Los Angeles, October 26, 1938. Reprinted by permission of the American Mining Congress.

* Director, Bureau of Mines, U. S. Department of the Interior

For purposes of this paper the minor metals may be classified into ferroalloying metals, light-weight metals, and miscellaneous metals. Time and space, however, permit only a few remarks on the more important in each group.

The ferroalloying metals, as the name signifies, are used extensively in ferrous metallurgy; consequently their market pattern follows in general the vagaries of the parent industry, but the extremes are not so pronounced. As a result of more exacting demands for performance under a given set of conditions, custom-made steels are becoming more important and the trend of American alloy steel production is steadily upwards. The utility of such steels is dependent upon the addition of one or more ferroalloying metals, including chromium, manganese, molybdenum, nickel, tungsten, and vanadium.

From the standpoint of quantity and value, manganese is first in importance. This element, essential in the present art of steel making, continues to be produced in large part in countries of small consumption, with the Union of Soviet Socialist Republics as an exception. Thus, manganese ore forms an important item in the imported raw materials of all steel-producing countries except the Union of Soviet Socialist Republics. Higher ocean freight rates and expanded demand have served to increase prices in recent years, but the low rate of activity in American steel mills in 1938 relieved pressure on world sources. American output, however, did not respond to the enhanced market conditions and, as in the past, our supplies are met very largely by imports. While deposits of varying grades and sizes are known to exist in a number of States, large deposits of acceptable-grade ore have not been found, nor have low-grade ore bodies susceptible to cheap methods of concentration been developed to the point where they are able to compete seriously with foreign deposits, despite varying degrees of tariff protection over the past fifteen years. Last year our imports of manganese ore for consumption were 911,922 long tons valued at $10,451,602, while domestic production was only 40,241 tons valued at $1,062,399. Thus in 1937, a year of near record production in the iron and steel industries, less than 10 per cent of our manganese requirements were met from domestic sources despite the high prices that were maintained.

Chromite is next in volume and perhaps in importance. The continued progress in the manufacture of alloy steels, particularly the development of stainless steels, has created increasing demands for metallurgical chromite. Expanded application is noted also in chemical and refractory outlets where lower-grade chromites, which are more abundant, may be used. Chromite, like manganese ore, is not produced to any great extent in countries where it is consumed, with the U. S. S. R. again the exception. In 1937, imports for consumption into this country reached the unprecedented total of 553,916 long tons valued at $7,324,488. And again we note that over 7 million dollars worth of raw material was purchased abroad. As in the case of manganese ore, domestic production is very small and while deposits of chromite are known to exist in this country they have been of little commercial importance in late years due either to grade or extent, or both. In 1937, shipments from domestic mines increased and

amounted to 2,321 long tons valued at $14,888, but previously shipments had been only a few hundred tons annually. The increase in 1937 was due to exploration and development by a domestic consumer in an endeavor to obtain supplies from deposits in California and Oregon. In this connection it is interesting to note that a domestic producer was the low bidder early in the year on 2,000 short tons of metallurgical-grade chromite to be supplied to the Navy for emergency stockpile purposes. It is understood, that no deliveries have been made as yet. Commercial shipments from the Philippines to the United States began last year and several deposits of high-grade metallurgical ore are being worked, but the large reserves often referred to are of the lower grade and not suitable for metallurgical uses unless beneficiated. Some of the shipments have gone to Japan.

China is the principal tungsten producer. Monopoly controls in that country, followed by a threatened blockade of Chinese shipments by the Japanese, have caused high prices to maintain for several years. Higher prices resulted in stimulating activities elsewhere and in 1937 our domestic production amounted to 3,500 short tons of concentrates (on the basis of 60 per cent WO_3). Imports of tungsten ore and concentrates (50 per cent WO_3 basis) in 1937 amounted to 5,842 short tons valued at $2,940,038. Thus, more than 60 per cent of our supply of tungsten in 1937 came from abroad. There has been much activity in tungsten exploration and development in our western States during the past few years and a number of new concentrating mills have been installed and equipped. The immediate future for tungsten, however, is beclouded by conditions in China, although supplies continued to come from this source despite the Sino-Japanese conflict.

In the molybdenum industry the situation is entirely different; molybdenum is one of the few ferroalloying metals of which this country has an ore supply ample for its own needs. The story of the phenomenal growth of molybdenum sales and of the Climax mine is well known to all of you, but it should be recorded that additions to mill capacity, completed in 1937, permitted treatment of more than 10,000 tons of ore a day. Despite the increase in capacity, the mill was pushed to meet orders last year. Of material interest is the recovery of molybdenum from the small fractional-per cent content in some of the American porphyry coppers. In 1937, the Utah Copper Co. recovered over 8 million pounds of molybdenite concentrates from its copper-milling operations. This company is now the second largest world producer with an output greater than the total of any country other than the United States. Molybdenite concentrates are also being recovered at Hurley, New Mexico.

Vanadium, alone or together with other alloying elements, finds wide application in alloy steels. Much of the vanadium used in this country in recent years came from Peru. However, domestic production in 1937 increased sharply as a result of the completion late in 1936 of the new plant of the U. S. Vanadium Co., at Uravan, Colo., to handle low-grade carnotite from Paradox Valley which cradled the domestic radium industry before it collapsed in 1923. As a result of this and other developments, this country will be less dependent than formerly on foreign sources for supplies of vanadium.

The chief light metals and components of light-metal alloys are aluminum and magnesium. The trend in the production and use of these metals is definitely upward and in 1937 new records were established. The decreased domestic industrial activity during the present year has been felt in these industries but curtailment has been less pronounced than for some of the other metals.

Light-weight metals and alloys find extensive use in the manufacture of both commercial and military aircraft. The bulk of the metal used in the fabrication of an airplane consists of aluminum, magnesium, or alloys thereof. And in this connection it should be noted that a large part of our airplane production is made on the West Coast—perhaps as much as 75 per cent in value. With recent advances in the treatment of magnesium alloys for corrosion resistance, there has been a greater demand for sheets, castings, and extruded products as construction materials. Continued research is broadening the field of application of aluminum and its alloys.

We, in the United States, are the principal producers and consumers of aluminum but about two-thirds of our primary production is derived from imported bauxite; the remaining third comes from the Arkansas deposits. A new plant using the Bayer process for the conversion of South American bauxite to alumina has recently been put into commercial operation at Mobile, Ala.; this plant will supplement the one at East St. Louis in supplying aluminum oxide to the aluminum reduction works. Plant expansion programs now in progress will increase materially the domestic ingot-production capacity and contribute to the future of aluminum. In the past, virtually all of the aluminum has come from bauxite but processes using clays, leucite, and alunite have been developed and are being tried in several countries.

Germany leads the way in magnesium, a result in part of the policy of using metals derived from available domestic raw materials. At present relatively more magnesium is consumed in Europe than in the United States, but it is believed that the time is not far off when domestic consumption here will increase materially. The entire production in this country comes from operations of the Dow Chemical Co., at Midland, Mich., where magnesium is obtained by the electrolysis of magnesium chloride which occurs in a natural brine pumped from wells 1,200 to 1,400 feet deep. Thermal reduction processes are being introduced in some European plants using magnesite or dolomite as raw materials. Our magnesium resources are plentiful since this metal may be produced from magnesite, dolomite, or even from sea water.

The United States is also an important market for a number of other metals, including antimony, arsenic, bismuth, and mercury.

Until the Laredo, Tex., smelter was built in 1930, the United States, like the rest of the world, was dependent mainly upon China for antimony. This smelter, which operates on Mexican ore, serves to prevent violent fluctuations in the volume and price of Chinese metal. The Sino-Japanese conflict caused great concern in world markets regarding the continuity of antimony supplies. Prices jumped and for a period of thirty days in 1937 quotations on Chinese metal were suspended due to lack of material. Subsequently, supplies from the Orient became plentiful and, with the lower demand in this country, prices fell rapidly and continued to decrease during the first half of

1938. While most of the antimony originates outside of the United States, a substantial tonnage of ore was shipped from Alaska last year, and it has recently been announced that the American Smelting and Refining Co. plans to build a by-product plant at Perth Amboy, N. J., capable of producing 50 to 75 tons of antimony daily.

War, likewise, has increased the significance of mercury. While there is a considerable domestic production, this country has for many years imported an important part of its requirements and the outcome of the struggle in Spain is the largest uncertain factor on the horizon at the moment.

Arsenic and bismuth are essentially by-product metals obtained from processing ores for the recovery of non-ferrous metals. World requirements for arsenic, chiefly for the control of insect pests, have been growing but not fast enough to offset the increased recoveries of by-product arsenic at smelting plants in several countries, notably Sweden. Domestic consumption of bismuth in low-melting point and non-shrinking alloys is increasing but pharmaceutical use remains by far the largest outlet.

Spurred by the need for processes that will enable domestic raw materials to supply the demand for minor metals, the Bureau of Mines has been conducting an extensive program of ore testing and metallurgical research. The ore testing studies have been continued to the point where many of the minor metal ores from various districts may be successfully beneficiated.

Of particular importance in the western part of the United States is the possibility of establishing electrometallurgical industries at points adjacent to adequate mineral supply and within easy reach of power developed by the various large river-control projects. The Bureau's approach to this problem has been based on the idea that the development of new materials for whose production the West has natural advantages would be of more value than an attempt to produce materials that are now made elsewhere, usually in ample quantities, by well-known methods.

An important objective of the program is to determine the possibility of producing deficiency metals, essential to armament and munitions, from domestic ores; and wherever possible to promote the production of these metals for peace-time uses and thus make them available in an emergency. The program includes such problems as the recovery of manganese, chromium, nickel, antimony, magnesium, and boron from well-known, readily accessible mineral deposits.

Excellent progress has been made. A method has been developed, and several hundred pounds of high-purity electrolytic manganese have been produced from ores containing from 16 to 40 per cent manganese. This electrolytic manganese, in contrast with the so-called pure manganese of commerce, which sells for about 40 cents per pound and contains amounts of aluminum and silicon that make it unsuited as a base metal for the preparation of alloys in the true sense, is an almost ideal material for an alloy base; and it is estimated that its cost will approximate 6 or 7 cents per pound. It has a silver color; it is permanent in air; and although brittle when pure, forms ductile alloys with relatively small additions of other metals. Its alloys with silver have been found to have exceptionally good properties for electrical contact mate-

rial. Preliminary experiments indicate that it may replace nickel and copper in such alloys as those of the monel, nickel-silver, and stainless-steel types.

The method is applicable to oxide and carbonate ores, the former being given a reducing roast to make them soluble in sulphuric acid. The manganese sulphate solution so prepared is then purified, ammonium sulphate and a small amount of sulphur dioxide are added, and the electrolysis is carried out in a cell with a canvas diaphragm. The power consumption is about 3 kilowatt-hours per pound of manganese for a pilot plant having a capacity of about 30 pounds per day.

Our work on manganese has been very favorably received, and it is reasonably certain that the metallurgical industry will carry on to the eventual commercial production of electrolytic manganese which will serve as an emergency source for this essential ingredient of ferromanganese. Thus the first step of the program has been completed.

Work is going forward, as our facilities permit, on the other objectives of the program, which, of course, could be accelerated with additional funds. It now seems probable that our recently developed method for the production of high-purity chromium metal will soon be ready for release to the industry. This method is based on chlorination of chromite ore, followed by gaseous reduction of the chloride to metallic chromium.

The laboratory phase of our investigation on the production of high-purity magnesium from magnesite is well in hand; and here again we are hopeful of overcoming the practical difficulties that have been encountered and of demonstrating the utility of a process that should make this valuable metal available in a high state of purity at a moderate cost.

A start has also been made on investigations relating to the recovery of nickel from domestic ores, the development of methods for the production of boron and its alloys, and of the treatment of antimony ores and alunite.

The importance of nonmetallic minerals is rarely appreciated by the layman and seldom by the metal miner. However, in terms of aggregate value of products and number of men employed, they run neck-and-neck with metal-mining, sometimes ahead. In volume of production they normally approach half a billion tons a year, or considerably more than double the ore output of all metal mines and more than ten times the annual tonnage of pig iron and nonferrous metals. Bigness alone is a faulty yardstick of national importance but from the standpoint of utility and general industrial and military significance, supplies of nonmetallic minerals are quite as essential as supplies of metals.

Most industrial minerals were produced in greater quantities in 1937 than in any previous year since 1930. Only a few, however, made all-time records and the group as a whole has by no means regained the ground lost since 1929. If account be taken of the 7,000,000 increase in population that occurred in the United States in this interim, the 1937 figures are even less encouraging.

The biggest industrial mineral industries are those that supply building materials, and such industries correlatively depend for their prosperity on new construction. A building boom is overdue. Statis-

ticians calculate a shortage of millions of homes, due not alone to population growth but also to the toll taken by fire and obsolescence. Despite great efforts of Federal, State, and local governments to revive building our best index of residential building has failed so far this year to advance much beyond one-third of what it was in 1928. Including all kinds of building—public, industrial, and residential—we were doing a little better at midyear, but not quite half so well as private industry alone was doing before the break. The building trades slumped some months before the general industrial crash of 1929, almost a decade ago.

Another large group of industrial mineral products is linked with the prosperity of the farmer and for two decades the farmer has been notoriously not prosperous. The Federal Government has furnished financial aid as well as instruction in the use of fertilizer, with the result that in 1937 fertilizer sales made a new record. This record, however, was only a trifle higher than the 1930 peak and no record at all would have been made had it not been for the Tennessee Valley Authority's distribution of superphosphate. Commercial sales were lower than in 1930. Fertilizer manufacturers, although they had to pay much more for labor, supplies, and taxes, advanced their prices only 6 per cent from September, 1932 to September, 1937, while prices of what the farmer sells rose 79 per cent and prices of commodities in general advanced 21 per cent. As in the building industry the difficulty is lack of effective buying power. Farmers know they can get bigger crops by buying more fertilizer but lack the money to buy it. Inasmuch as chronic farm surpluses already constitute a major national problem, one wonders, too, what would happen if all farmers should buy more fertilizer and so grow bigger crops. Home markets for foodstuffs have almost ceased to expand, and export markets no longer absorb all the foods and fibers we can grow. Human wants for things other than food are not limited. You may sell a man an extra pair of trousers or even a second automobile when you can not sell him an extra loaf of bread. By growing things that chemists can transform into paints, textiles, rubber, or plastic products, for example, the farmer may remedy his present plight, but, like Rome, such new markets are not built in a day, and meanwhile fertilizer sales are slightly lower in 1938. Since only about two per cent of the gross farm income seems to be available for fertilizer purchases, I may point out as one more hurdle the fact that the farmer pays 90 cents a unit for phosphoric acid that the miner sells for 9 cents.

A third broad group of nonmetallic minerals comprise those that are used directly in manufacturing industries that do not cater so exclusively to builders or farmers, and wherein technologic advances that lower costs or improve products may be reflected quickly in larger sales. The glass, paint, paper, rubber and certain ceramic industries are among those that at times have managed to lift themselves above their 1929 peaks and such industries are demanding, and getting, more and better materials from mines and quarries.

By borrowing ideas from the metal mining fraternity and using their own brains as well, industrial mineral producers have refuted the doctrine that it does not pay to try to beneficiate materials that sell for less than $5 or even $1 a ton. They have also refuted the idea

that because most industrial minerals are valued for their physical properties they can not be improved much beyond the state in which Nature left them in the ground. We do not know yet how to melt and recast a marble column that develops a flaw but we can take a clay apart and put it together again so that it may better serve our needs, and in many ways we are less dependent upon naturally high-grade deposits. We used to imagine that the United States was dependent upon imported clays for making fine pottery and paper, on imported chalk for whiting, on foreign graphite and mica for their important uses, and so on. We wasted half the phosphate rock we mined and were dependent utterly upon a German monopoly for potash and on a Chilean monopoly for fixed nitrogen. A Chilean monopoly likewise supplied the world's iodine at a fancy price and all the magnesite for our steel furnaces had to come from across the Atlantic. Many of these minerals we still import but largely now because we find it convenient. I doubt if a case of real necessity for imports could be sustained except perhaps for mica, asbestos, and certain optical crystals—and recently we have heard that a suitable substitute even for mica can be centrifuged from bentonite.

Our bentonite industry is another fruit of technologic progress. Vermiculite, pyrophyllite, and the kyanite-sillimanite group of minerals, likewise, are newcomers in the industrial mineral field. Certain lithium minerals are reaching out for new markets and the tremendous growth of our California borax industry is nothing short of astonishing. Let me mention, too, the acceptance of feldspar by the glass industry which is beginning also to consume Canadian nepheline syenite, another newly commercialized material. Sales of talc and pyrophyllite showed a 10 per cent gain in 1937 largely because of the vogue in America for more bathrooms, more tiles in bathrooms, and more talc and pyrophyllite in tiles. The boom in house insulation in late years has created not only the vermiculite industry but the much larger mineral wool industries. We are bettering our talc by froth flotation and this process also has been economical in treating so cheap a material as cement rock. The boldness with which this matter of economic supply of industrial minerals is being attacked is illustrated further by the successful extraction of bromine from seawater on the Atlantic Coast and of magnesium salts on the Pacific, as well as separation of nitrogen from the air.

In conclusion I should like to touch upon the growing importance of industrial minerals as by-products of metal-mining enterprises. We can scarcely hope to match the pork packers in utilizing everything but the squeal. Nevertheless, modern concentrating technique can separate pure minerals so cleanly that a microscopic study of the gangue may suggest new sources of revenue. Many of us can remember how difficult it used to be to separate zinc and lead, or later, zinc and pyrite, and all of you are familiar with the possibility now of making a pyrite concentrate that can be used for making acid from mixed sulphide ore. You may have heard how Denver sand and gravel operators began years ago to run their product through sluice boxes to extract gold although the gravel tailings were in fact their main product. At Eastern iron mines the production of crushed stone, stone sand, and even chicken grit has become an important adjunct

to more traditional mining operations. Glass sand or refractory sand may be reclaimed from concentrator tailings in some localities and any finely divided product or slime may have use as a filler. Rock wool is a possibility in fairly thickly settled communities—or slag wool if there is a smelter. Feldspar and ground mica are potential by-products of ores found in igneous rocks while limestone tailings have numberless possibilities ranging from agricultural lime to precipitated chalk for toothpaste. Fluorspar, phosphates, rutile, zircon and perhaps rare earth minerals should be looked for. Bureau of Mines tests show that even potash could be recovered in enormous quantities from porphyry-copper mill tailings. Repeatedly we have seen the tailing piles and waste dumps of a previous generation reworked for the metals they still contain and it is time to appraise them, also, as potential sources of industrial minerals.

THE RIGHT TO MINE [1]

By Robert M. Searls *

The subject which I have been asked by the officers of the American Mining Congress to discuss today is so broad in its scope that an encyclopedia might easily be written to cover it. The right to mine dates from the time when Neanderthal man, by the use of brute force, carved from the rocks a suitable stone hatchet and used the product of his labor to enforce his rights if his neighbor objected to the operation. It is a long step from this simple law of might down to the time when the Federal government says to the mine operator, ''Go to jail,'' if you say good morning to a competitor, because you are violating the anti-trust laws; or ''Go to jail,'' if you say good morning to your employees, because you are violating the Wagner Act. The right to mine—that is, to extract minerals from the earth—is one of the earliest privileges sought after and enjoyed by the human race. Its regulation has likewise been a matter of age old legislation.

On the continent of Europe the so-called regalian doctrine existed, under which the ownership proper of all metals was vested in the sovereign. This was particularly true with respect to gold and silver. This regalian doctrine also prevailed as to gold and silver mines under the common law of England, but as there were no gold and silver mines in England, it did not have so much bearing there. Other minerals were held to be the property of the owner of the land under English law. Where the regalian doctrine prevailed, the right to mine was contingent upon the payment of a royalty to the crown and making arrangements with the owner of the surface for mine operation. Outside of exacting this royalty, history does not indicate that the sovereign was particularly interested in regulating the miner's means and method of operation. Means, methods and customs of mining developed in the coal mines of the Black Forest, in the iron mines of Bohemia, in the tin mines of Cornwall, in the lead mines of Devonshire, and elsewhere, until, with the advent of the machine age and all the modern equipment of mining, we have the complex operations of the present day.

In the United States little attention was paid to the regulation of mining for many years. While gold had been found in moderate quantities among the Indian tribes of the southern states, and copper was known to exist in the Lake Superior region, little metal mining was done by white men on the North American continent prior to the year 1800. The one possible exception to this statement is the mining of lead in what is now Missouri as early as 1720. In 1807 Congress passed an act reserving lead mines in Indiana territory for lease by the Federal government. Leasing was done under the supervision of the War Department on a six per cent royalty basis. The leasing plan was not a success. The frontier country was settled up. Illegal entries of mineral land were made under agricultural laws, the smelters and miners refused point-blank to make any further royalty payments, and

[1] Presented at meeting of American Mining Congress, Los Angeles, October 26, 1938. Reprinted by permission of the American Mining Congress.

* Attorney, San Francisco, California.

the government was unable to collect them. In 1847 it was finally concluded that the only practical solution was to sell the mineral land and do away with all attempts to reserve royalties on lead or any other metals, since they had only been a source of embarrassment to the Department. This decision was followed by the Act of March 1, 1847, for the sale of mineral lands in the Lake Superior districts in Michigan and in Wisconsin.

The discovery of gold in California in 1848 precipitated another controversy. California, prior to its cession, had been under Mexican law, rules and customs. The cession of the state to the United States following the war of 1848 with Mexico came just prior to the discovery of gold. The result was that the placer diggings in early California rapidly filled up with a large influx of miners from all over the world, each bringing his own ideas of laws and customs. The Mexican idea of appropriation by the discovery of mineral was adopted as a basis for procedure in the various camps. Miners from Cornwall soon spread themselves through the State and, largely by their experience, practical sense and industrious habits, helped to evolve something like a system of rules and regulations which was embodied in the district rules and regulations of miners. The substance of these rules was enacted in the Civil Code of the new State of California following its admission in 1850. But the state could not vest titles as against the Federal government.

In December, 1849, President Fillmore recommended that the mineral lands in the far west be divided into small parcels and sold under such restrictions as to quantity and time as would insure the best price and guard most effectually against combinations of capitalists to obtain monopolies. However, Congress did nothing about the matter until 1866, when the first lode mining act was passed covering operations on public lands. The miners' rules and customs which had been in effect for sixteen years were given express recognition and the status of statutory law. The only regulations contained in the act related to the manner and means of acquiring title. This act was not an entire success because it did not adequately determine the rights of the miner as compared with those of the surface owner. It was superseded by the Placer Act of 1870 and the present lode law of 1872. These acts provided the ways and means by which the miner might become vested with a fee title to his land, having all the dignity and characteristics of any other land titles, with the exception that following the miners' custom, extra-lateral rights were declared to be appurtenant to the claims in which the apices of the veins were found.

It may therefore be said that since 1872 the metal miner has, so far as title to his land is concerned, enjoyed a position comparable and in some respects even superior to that of the owner of a non-mineral title. The right to mine, so far as the Government was concerned, was vested in the land owner without royalty and without limitation except such as might be common to all industries. Therefore, with respect to titles, we may say that the government did all that it could or should do to encourage the mining industry. There are many other factors, however, which vitally affect the right to mine. One of them is taxation.

The application of the property tax to mining lands was the natural sequence of the establishment of orderly government in mining regions.

It is a form of taxation to which all American citizens are accustomed. Where it is reasonably applied the mine owner has never been in the least unwilling to bear his share of the cost of government as levied under this form of taxation. There has been a tendency in the counties of California in which oil is produced for the assessors to separately assess mineral rights which are often held under leases, on the basis of past year's production. This is in effect the levy of a severance tax, of which I shall shortly speak. It is clearly not a proper measure of the value of the mineral rights because the mineral which has been produced is no longer a part of the property and the property is that much less valuable. However, this practice is followed in a state which has as yet no severance tax applicable to the production of its natural resources, and so far as I am advised, this method of assessing oil lands is not followed in other localities where metals are produced. The problem of fairly assessing mine property for tax purposes is a broad one, requiring consideration by the local taxing authorities of the past history of the property, the average value per unit of ore that has been produced, the probable value in the ground of ore that is left, and the general policy of encouraging mining industries in a given section by conservative assessment.

So far as metal mines are concerned, I do not believe that there is much to complain of concerning the property tax except in those states where it is levied in addition to a severance tax. It seems clear that a state should not levy both a property tax and a severance tax because to do that amounts to double taxation of the same property. Mining property seldom has any substantial value except for the minerals it contains and if the State by a statute levies a severance tax on the right to extract those minerals based on a percentage of their gross value—as is usually the case—it is certainly double taxation to again assess the property for local taxation on a property value basis. This is contrary to established principles of taxation.

The next form of tax commonly imposed on mining companies was the corporate franchise tax, which is in effect a state income tax on the mining company's net income. Here again the mining industry has no particular complaint because it bears a rate common with all other industries, provided that the state authorities allow, as they usually do, a reasonable deduction for depletion of wasting assets in computing the net income.

Another burden was then laid on the industry in some states in the form of sales taxes on all materials and supplies consumed, and use taxes on machinery and equipment purchased outside the state. In California one attempt was made to include gold bullion in the list of taxable sales, but it was defeated by legislators friendly to the industry.

Following these taxes we have federal corporate income taxes, to which I shall not go into detail except to point out in passing that the corporate undistributed profits tax just modified by Congress had a highly detrimental effect on the expansion of mining. With no opportunity to obtain an exemption from taxation of surplus earnings applied to capital expenditures in equipping and developing mining property, a penalty was placed on the accumulation of corporate surpluses which make the expansion of mining possible. It is to be hoped that the present modification of this law will be retained and even extended

so as to eliminate such an unjust form of taxation as the undistributed profits tax altogether.

Another recent form of taxation affecting mines has been the severance tax levied by various states. This tax goes back to the regalian theory that the metals belonged to the sovereign, not to the owner of the soil and that the right to extract the same is an appropriate basis for taxation. In modern days it is sometimes twisted into saying that the natural resources belong to the people; that the exhaustion of these resources depletes the people's wealth, and that the people should receive a share in the form of taxation. The utter fallacy of this reasoning under the American system of absolute title to the minerals being vested in the owner of the surface is apparent. There is no more justification for taxing the miner for the privilege of extracting the mineral from his land than there is for taxing the farmer for the privilege of raising wheat on his. To this, the proponents of the severance tax say that the farmer does not destroy the taxable value of his land, while the miner does. This contention is easily answered—the miner by his diligence adds to the surface value of land containing minerals a temporary mineral value which it never had before. Under the property tax laws he is taxed on that additional value during the period that the minerals are being extracted and sold. After they are gone, the temporary value no longer exists and the land reverts to the surface value which it always had. This is true for all forms of mining except hydraulic mining and dredging, which may destroy small surface values, and it is equally true for lands found to contain oil. A severance tax added to a property tax is therefore a rank discrimination against the miner and an unjust encumbrance on the right to mine. South Dakota has the worst example of discriminatory taxation perhaps, with a six per cent gross bullion tax, exempting the first ten thousand tons of ore mined annually. It is obviously aimed at one large operator, and is levied in addition to the general property tax. In some states the severance tax is justified as a lieu tax—that is, in place of property taxes; but the objection here is that it becomes a special tax on a limited industry, and once imposed, control over the rates rests exclusively with the legislature. They may be placed entirely out of line with property tax rates, with the miners politically helpless to protect themselves. The general taxpayer who is not affected by the tax will ordinarily not be interested unless his purse is also tapped. This is the great objection to special forms of taxation like the severance tax.

Another qualification on the right to mine in recent years has been the constantly expanding exercise of the police power by both the State and Federal government. Starting with the anti-debris law, which practically ended hydraulic mining in California for forty years, and continuing on through all the range of laws limiting the hours of labor in underground mines, directng the payment of wages, imposing regulations for the safety of employees, providing compensation and social security insurance, prohibiting or regulating the pollution of streams from mine tailings, and regulating the terms upon which securities for the financing of mines may be offered and sold, the right to mine has been severely trammeled with legislative and administrative restrictions of many kinds and descriptions. Some, but far from all of these regula-

tions have become necessary in a modern age to correct abuses which have grown up, and to protect the lives, health, and well-being of citizens. Up to about two years ago most regulations were imposed by state laws and were enforced by state officials cognziant of and familiar with the industrial problems that confronted the mining industry within their borders.

Commencing with the enactment of the Wagner Act and continuing through the Securities Exchange Act, and now the Wage-Hour Act, the Federal government has stepped into the picture with a heavy tread. No longer may the miner rely upon practical and sympathetic consideration of his individual problems. Arbitrary policies fixed in Washington, often adopted in conference committees of Congress where he has no opportunity to be heard, enforceable with atrocious penalties—both civil and criminal—threaten the very existence of the metal mining industry. The operator may not deal with his own employees or sometimes even with the union of their own choosing, if the National Labor Relations Board in its supreme discretion considers that a C. I. O. union would be a better bargaining agency. The operator is informed under the new Wage-Hour Act that although he is carrying on a continuous process industry, he may not work his employees more than 40 hours a week without paying them time and a half for overtime. On what valid theory of exercise of the police power can this enactment be justified? Conceding for the purpose of argument that wages up to 40 cents per hour maximum enforceable by law under the act should be paid as necessary for the health, comfort, and well-being of the workers; conceding, for the purpose of argument also, that a forty-hour week is necessary for the well-being of the workers and the curing of unemployment, or a thirty-five hour week, or a thirty-hour week, if the latter will please some of our labor friends better—*what possible justification* is there for permitting a violation of these maximum hours *upon the condition that you pay employees time and one-half for the overtime?* If wages exceed the minimum and even the maximum prescribed by the act, and the regulation of hours to any specified number in the interests of health, safety, and nation-wide unemployment is a valid exercise of the police power, how can Congress justify a departure from this standard upon the condition that time and one-half shall be paid for overtime? In my humble opinion the provisions of Section 7 of the Wage-Hour Act are a violation of the constitutional guaranty of freedom of contract, and can not be supported as a valid statute under any known theory of exercise of the police power in the United States. Those who would continue to enjoy the right to mine should stand shoulder to shoulder in a demand that this outrageous imposition on industry be modified so as to permit its continued existence in compliance with law.

Hand in hand with the Wagner Act and Wage-Hour Law, have gone Social Security laws and tremendous increases in compensation awards for injuries. These indirect costs of mine labor in California under these latter laws is nearly fifteen per cent of the pay rolls—in an industry where increased costs must be absorbed and can not be passed on.

The Securities Exchange Act is another highly troublesome impediment to the exercise of the right to mine, particularly by the small

operator who desires to finance development of his property through a public offering of capital securities. Designed by its framers to protect the investing public against nation-wide flotation of spurious securities, the commission organized to administer the act has with usual Washington sang-froid passed out regulations by the hundred, without any regard to their necessity, desirability or the cost of complying with them. Statements are required necessitating the employment of certified accountants, engineers, and attorneys at a cost which is in many instances prohibitive to the small operator. The need for these statements is not clear. Mining is at best a speculative venture. The people who buy mining stocks in new mining ventures know that they are going into a speculative type of investment. Assume that the promoter may be and should be held criminally responsible for making false statements in his prospectus which are not warranted by facts within his knowledge. Assume also that neither he nor any one else can tell with any assurance whether or not he is going to find ore in his development, and if he does find it whether or not it will be a paying venture. Wherein is the public benefited by the opinion of a mining engineer as to whether or not he will be successful, the certification of a public accountant that his books have been properly kept, and the opinion of any attorney that he has legal title to his land? Any one of the three experts may be wrong. If the Securities Exchange Commission approves the issue it will be just that much more inducement for people to put their money into mining securities who would not embark on such a hazardous investment were it not for the certificate of some government commission. My point is that the permit of the Securities Exchange Commission adds very little to the safety of present day mining investments, and is apt to create a false sense of security in the prospective investor. Each of the states has its own blue sky law and its own corporation commissioner whose permit must be obtained before such securities can issue. Mining securities have not been the worst offenders on any of the country's major exchanges. It would seem that the Securities Exchange Commission might well justify more leniency in its permits to mining operators than the past has indicated.

I have outlined in brief detail the history and development of restrictions on the right to mine. The mine operator has been caught in the current of this experimental social regulation which permeates our whole government structure in this present day. He is embroiled in the clash of philosophies which rocks America and, indeed, the whole world. The gold miner in particular is badly hit because he can not add the cost of this regulation to the price of his product. The miners of other metals are not much better off because they must compete in the world market with producers who are not subject to this expensive regulation. The ultimate solution no one can foresee. One thing seems sure, however. Metal mining will always require large capital investment. Capital will not work in a hazardous enterprise indefinitely without adequate compensation. If our properties are shut down the ores will still be in the ground, and the capitalist can in most instances bide his time to extract them. But how about the workers—the hundreds of thousands of employees in metal mining? How about the local merchants in the sparsely settled country in which these mines

operate? How about the entire localities of people which their enterprise supports? Here is where confiscatory regulation will back up on itself and result in an outcry to which Washington and the State Legislatures sooner or later must give ear.

There are already hopeful signs. Vehement protests are becoming stronger and stronger against the unfair and highly discriminatory decisions under the Wagner Act; the hampering provisions of the Wage-Hour Act, and the discriminations of the tax laws. The Circuit Court of Appeals of this circuit, in a courageous and well-reasoned opinion, has held that the Wagner Act does not apply to a purely intrastate industry like gold mining. We may hope that the Supreme Court will uphold it. The strong argument against the enactment of the Lonergan stream pollution bill which was voiced by The American Mining Congress, in conjunction with other industries, blocked its enactment. In every state the mining industry is organized as never before to fight for its existence before legislators and administrative tribunals. Its associations have for the most part made The American Mining Congress their spokesman and voice in Washington. Cooperation and organization are beginning to get results. The industry must forget some of its individualism—must cease to be an industry of separate units merely because most of its members are geographically widely separated. It must speak to and act toward the administrators of a democratic government so vigorously that law makers and administrative tribunals alike will recognize the justice of its contentions. The right of American citizens to mine must not cease to exist. It should and must continue in the future, as it has in the past, as one of the most important factors in meeting the material demands of our modern civilization.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

Albert H. Ricketts, attorney, and author of ''American Mining Law,'' published in 1931 as Bulletin 98 of the Division of Mines, passed away at his home in Berkeley, November 27, 1938, at the age of eighty-nine years. He was the oldest living member of the California Bar Association.

Mr. Ricketts was born in British Guiana, and came to the United States as a child. He was admitted to the bar in Nevada City in 1868, and at one time in his career was an assistant attorney general of the State of Nevada. His father was Samuel Ricketts, a barrister in London, England. He is survived by his widow, Mrs. Julia Ricketts, and by two sisters, Mrs. Ann d'Ancona and Mrs. Hilda Macdonald Hart, both of Berkeley.

At the time of his death, Mr. Ricketts was engaged in preparing a revision of our Bulletin 98, which he had nearly completed. We expect to put the finishing touches on it and publish it later in the current year.

New Publications.

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, July, 1938, being Chapter 3 of State Mineralogist's Report XXXIV. This chapter contains: "Mineral Resources of El Dorado County," with mining claims map. "Strategic Minerals in California"; "Submarine Canyons Off the California Coast"; the following special articles: "The Mountain Copper Company, Ltd., Cyanide Treatment of Gossan"; "Use of Ultra-violet Light in Prospecting for Scheelite"; "New State Lands Act of 1938"; "New Amendment to the 'Caminetti Act,' 1938"; also a summary of the 1937 Mineral Production of California, and a list of specimens recently donated to the Mineral Exhibit of the Division of Mines.

COMMERCIAL MINERAL NOTES (Nos. 187-189 incl.) November, December, 1938, and January, 1939, respectively. These 'Notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to four pages in recent months.

Mail and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

CALIFORNIA MINERAL PRODUCTION FOR 1938 SHOWS INCREASE

The total value of the mineral production of California for the year 1938, just closed, is conservatively estimated by the Statistical Section as $369,751,000. This is partly detailed in the tabulation below, but as there are more than 55 mineral substances on California's Commercial list, figures on the most important items only are available at this early date. The production report forms are being mailed to the operators in all mineral lines, and the detailed and completed report will be compiled and published later.

The estimated total of $369,751,000 is an increase of approximately $8,135,000 over the 1937 total value, and is the largest since 1929. The principal increases in value over those of the previous year were shown by petroleum, gold, natural gas, and quicksilver. The only important mineral substances to register decreased values were miscellaneous stone, brick and hollow building-tile, silver, copper, and lead.

Both value and amount of the petroleum output showed increases with a total quantity of about 249,852,000 bbls., which is about 5% over that of 1937. There was little or no change in the price paid to producers by the refineries. There was an increase in the amount of natural gas utilized, thereby increasing its total value over that of the previous year.

Receipts of bullion at the mint and smelters showed an increased output of gold of some 119,822 fine ozs. Thus, 1938 had the highest annual gold value since 1861, and the largest yield in fine ounces since 1862. The silver and quicksilver yield each had a total value over the million-dollar mark. The output of silver, copper, lead, and zinc, showed a decline from that of 1937 owing to market conditions.

Of the structural group, these materials as a whole showed a decreased production and value from that of the previous year. Although building permits in 51 principal cities of the state increased approximately 8%, large public construction was less than in 1937 as many larger projects were completed early in the year. Both the miscellaneous industrial and saline groups showed small changes in their total values.

The estimated values and quantities for 1938 are as follows:

$45,304,000	(1,294,000 fine ozs.) gold.
1,681,000	(2,755,000 fine ozs.) silver.
217,000	(2,210,000 lbs.) copper.
41,000	(1,000,000 lbs.) lead.
825,000	(11,500 flasks) quicksilver.
1,388,000	Other metals including chromite, iron ore, platinum, tungsten ore, etc.
249,714,000	(249,852,000 bbls.) petroleum.
21,228,000	(348,000,000 M. cu. ft.) natural gas.
16,973,000	(10,608,000 bbls.) cement.
9,800,000	crushed rock, sand and gravel.
2,900,000	brick and hollow building-tile.
1,280,000	other structural materials, including bituminous rock, granite, magnesite, marble, sandstone, slate, etc.
5,600,000	miscellaneous industrial materials.
12,800,000	salines, including borates, potash, iodine, salt, soda, etc.
$369,751,000	Total.

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20893 CALCITE—$CaCO_3$ (calcium carbonate) with SULPHUR—S. From Girgenti, Sicily.
Donor: Crocker Art Gallery, October, 1938.

20894 GOLD ore—Assay value, $130 to $220 per ton. From Miss Geneve Claim, Sweet Water District, Mariposa County, California.
Donor: G. A. Shaffer Mining Dep't November, 1938.

20895 TRONA—$Na_2CO_3.HN_aCO_3.2H_2O$—hydrous carbonate and bicarbonate of sodium. Crystals from well drill-core, depth 75 ft.-80 ft. From Searles Lake, San Bernardino County, California.
Donor: A. A. Hoffman, General Manager American Potash & Chemical Co., Trona, December, 1938.

20896 HANKSITE—$9Na_2SO_4.2Na_2CO_3.KCl$—hexagonal crystals; and SULPHOHALITE—$2Na_2SO_4.NaCl.NaF$ (octahedrons). From well drill-core, depth 75-80 ft. From Searles Lake, San Bernardino County, California.
Donor: A. A. Hoffman, General Mgr., American Potash & Chemical Co., Trona, December, 1938.

20897 APHTHITALITE (Glaserite) potassium sodium sulphate, from well drill-core. From Searles Lake, San Bernardino County, California.
Donor: A. A. Hoffman, General Mgr. American Potash & Chemical Co., Trona, December, 1938.

20898 TRONA—$Na_2CO_3.HNaCO_3.2H_2O$—hydrous carbonate and bicarbonate of sodium. Crystals from well drill-core depth about 300 ft. From Searles Lake, San Bernardino County, California.
Donor: A. A. Hoffman, Gen. Mgr. American Potash & Chemical Co., Trona, December, 1938.

20899 HANKSITE—$9Na_2SO_4.2Na_2CO_3.KCl$—Prismatic crystals (3) with basal terminations. From well drill-core, depth 75-80 ft. From Searles Lake, San Bernardino County, California.
Donor: A. A. Hoffman, Gen. Mgr. American Potash & Chemical Co., Trona, December, 1938.

20900 HANKSITE—$9Na_2SO_4.2Na_2CO_3.KCl$—hexagonal, pyramidal crystals. From well drill-core, depth 75-80 ft. From Searles Lake, San Bernardino County, California.
Donor: A. A. Hoffman, Gen. Mgr. American Potash & Chemical Co., Trona, December, 1938.

20901 GAY-LUSSITE—$CaCO_3.Na_2CO_3.5H_2O$—hydrous sodium-calcium carbonate. Crystals from well drill-core. From Searles Lake, San Bernardino County, California.
Donor: A. A. Hoffman, Gen. Mgr. American Potash & Chemical Co., Trona, December, 1938.

20902 GLASS SAND. Cleaned and washed, to less than 0.05% Fe_2O_3. From Weisel Sand Plant, Corona, Riverside County, California.
Donor: G. A. Van Valin, January, 1939.

20903 DOLOMITE (orbicular). From Coyote Hills, Santa Clara County, California.
Donor: G. and L. P. Bolander, January, 1939.

20904 CINNABAR (HgS), with native MERCURY. From Contact Mine, Pine Flat, Sonoma County, California.
Donor: E. P. Stites, January, 1939.

20905 MALACHITE in quartz with some hematite. From Death Valley, Inyo County.
Donor: Death Valley Curly, January, 1939.

20906 Cluster of TOURMALINE Crystals. Tourmaline is a complex aluminum borosilicate. From Riverside County, California.
Donor: Joe E. Field, February, 1939.

20907 GARNET almandite variety. From four miles from Rushmore, Memorial, Black Hills, South Dakota.
Donor: Ernist W. Hoffman, February, 1939.

20908 Native COPPER in serpentine. From six miles west of Monticello, Napa County, California.
Donor: C. Cicero, February, 1939.

20909 GARNET in hornblende, from Gore Mountain, New York. These are commercial garnets used in the manufacture of garnet paper.
Donor: John H. Esselink, March, 1939.

20910 THENARDITE—Na_2SO_4, sodium sulphate, from Rhodes Marsh, Nevada.
Donor: John H. Esselink, March, 1939.

20911 ALLADINITE (Jasper) from Wabuska, Nevada.
Donor: John H. Esselink, March, 1939.

20912 ROMERITE—$FeO.Fe_2O_3.4SO_3.14H_2O$, a hydrous iron sulphate, in cavities in pyrrhotite. From Island Mountain, California, the only location in the United States this mineral is found.
Donor: John H. Esselink, March, 1939.

20913 CINNABAR Nugget, from Oceanic Quicksilver Mine, Cambria, San Luis Obispo County, California.
Donor: M. J. O'Boyle, March, 1939.

20914 TUNGSTENITE—WS_2(?)—tungsten sulphate. From Emma Mine, Little Cottonwood District, Utah.
Donor: Victor C. Heikes, March, 1939.

20915 GOLD (Au) in BARITE ($BaSO_4$). From Trophey Mine, Copperopolis, Calaveras County, California.
Donor: W. G. Pettibone & Sons, March, 1939.

20916 CINNABAR (HgS) and STIBNITE (Sb_2S_3). From Ibapah Mine, Ibapah, Utah.
Donor: H. W. Gould, March, 1939.

20917 ARROWHEADS, *Flint.* From Flint Range, three miles north of Brownsville, Licking County, Ohio.
Donors: Albert Loughman and Herman Brown, March, 1939.

LABORATORY

George L. Gary, Acting Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one "Minerals of California," by Adolf Pabst, was published this year by the Division of Mines as Bulletin No. 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

14. Lazulite, a basic aluminum iron and magnesium phosphate occurs as bands in a garnetiferous quartzite from Alpine County.

15. Spessarite, a manganese—aluminum garnet from Riverside Co.

16. Melanterite, a hydrous ferrous sulphate occurring in small green and white fibrous crystals, from 6 miles south of Escondido, San Diego County.

17. Samarskite (niobate and tantalate of iron, calcium, uranium oxide, etc.) a velvet-black patent leather looking mineral was found associated with xenotime, monazite, tourmaline, orthoclase and garnet in the Southern Pacific silica quarry, ½ mile southeast of Nuevo, Riverside County.

18. Bulletin No. 113, page 104, Stibiconite, Kern County. Stibconite should be stibiconite.

19. Native copper in serpentine was found 6 miles west of Monticello, in Napa County.

20. Iddingsite, a hydrous magnesium and iron silicate associated with green and red olivine has been found between Amboy and Bagdad, San Bernardino County, Calif.

LIBRARY

JOHN C. O'BRIEN, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, CALIFORNIA JOURNAL OF MINES AND GEOLOGY contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the state are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:

Bulletins:

896 Lexicon of Geologic Names of the U. S. Part 1, A-L, Part 2, M-Z.

Water Supply Papers:

830 Surface Waters Supply of the U. S., 1937, Part 10, The Great Basin.
832 Pacific Slope Basins in Washington and Upper Columbia River Basins.
840 Water Levels and Artesian Pressure in Observation Wells in the United States in 1937.

Topographic Maps:

Blairsden Quadrangle, Advance sheet.
Kramer Quadrangle, Advance sheet.
Lakeport Quadrangle.
Little Tujunga Quadrangle, Los Angeles County.
Mojave Quadrangle, Kern County.
Rogers Lake Quadrangle, Advance Sheet.
Tejon Quadrangle.

Map of Yosemite Valley, Yosemite National Park, California. Mariposa County. Scale $\frac{1}{24000}$ or 1 inch to 2000 ft.

Contour interval 50 feet.

District Boundaries and principal Field Offices, Water Resources Branch, U. S. Geological Survey.

Federal Board of Surveys and Maps:

Map showing status of Aerial Photography in the United States. Scale $\frac{1}{5000000}$ prepared April 1938.

Departmentof the Interior:

Federal Lands of the United States.

Vegetation types of California (Exclusive of Deserts and Cultivated Lands). Redding Quadrangle.

U. S. Bureau of Mines:

Bulletins:

415 Studies of Certain Properties of Oil Shale and Shale Oil.
416 Quarry Accidents in the United States, 1936.

Technical Papers:

588 Metallurgical Developments at Mercur, Utah.
591 Federal Placer Mining Laws and Regulations.
Small-Scale Placer-Mining Methods.
592 Flow of Air and Natural Gas through Porous Media.

Circular:

37 Safety Education in Schools of Mining Districts.

Report of Investigations:

3423 Chemical and Refining Study of Some Wyoming Black Oils, by H. M. Thorne and Walter Murphy.
3424 The Agglomerating Index of Coal, by J. F. Barkley and L. R. Burdick.
3425 Progress Reports—Metallurgical Division 27. Ore-testing Studies. 1937-1938. Special Methods of analysis and testing and details of tests on various ores.
3426 Some tests of acid-resistant pipe by R. D. Leitch.
3427 Annual report of the nonmetals division. Fiscal year 1938, by Oliver C. Ralston and others.
3428 Carbonizing properties of a Subbituminous Coal from Puritan Mine, Dacono, Weld County, Colo., by J. D. Davis and V. F. Parry.
3429 Cooperative Fuel Research Motor-Gasoline Survey. Summer 1938. Compiled by E. C. Lane.
3430 Survey of Fuel Consumption at Refineries in 1937, by G. R. Hopkins.
3431 House movement caused by ground vibrations, by J. R. Thoenen and S. L. Windes.
3432 Primary Crushing. Summary of Field Tests, by Mark Sheppard.
3434 Typical oil-field brine-conditioning systems: Preparing Brine for subsurface injection.
3436 Progress Reports Metallurgical Division. Some Factors Affecting the Flotation of Silver Minerals, by E. S. Leaver and J. A. Woolf.
3439 Mount Weather Testing Adit, Progress Report 1, by McHenry Mosier and Wing G. Agnew.

Information Circulars:

6699 R Laboratories that Make Fire Assays, Analyses, and Tests on Ores, Minerals, and Other Inorganic Substances, by C. W. Davis and M. W. Von Bernewitz.
7039 Gold Mining and Milling in Idaho County, Idaho, by S. H. Lorain.
7040 Coal-Mine Explosives: Their Characteristics, Selection and Safe Use, by J. E. Tiffany.
7041 Forwarding Health and Safety in Coal Mining by use of watering methods by D. Harrington and J. J. Forbes.

7042 Ichthyol—Its Source and Properties, by O. C. Blade.
7043 Reconnaissance of Mining Districts in Lander County, Nevada, by William O. Vanderburg.
7044 Installation of High-Tension Power Circuits in Coal Mines, by E. J. Gleim.
7045 An explanation of washability curves for the interpretation of Float-and-Sink date on coal.
7046 Safe Storage, Handling and Use of Commercial Explosives, by D. Harrington.
7047 Mine Ventilation, by D. Harrington.
7048 Coal-Mine Explosions and Coal- and Metal-Mine Fires in the United States during the fiscal year ended June 30, 1938, D. Harrington and W. J. Fene.
7049 Gypsum and Anhydrite by Forrest T. Moyer.
7050 Mine Safety Board Decision 30, Main Fan Installations at Coal Mines, by Mine Safety Board.
7051 First-Aid Training and Results in Logan and Mingo Counties, W. Va., by H. J. Van der Veer and Ray Ellis.
7052 Annual Report of Research and Technologic Work on Coal Fiscal Year 1938, by A. C. Fieldner.
7054 Lithium by Frank L. Hess.
7055 Annual Report of the Mining Division, Fiscal Year 1938, by Chas. F. Jackson.
7057 State Regulations pertaining to Hoisting of Men, by L. C. Ilsley and E. J. Gleim.

Books:

Annual Report of the Chief of Engineers, U. S. Army, 1938; parts 1 and 2: Vol. 1 and 2.
Annual Reviews of Petroleum Technology. Vol. 3, covering 1937.
The Colorado Delta, by Godfrey Sykes. American Geographical Society
The Engineering Index, 1937.
Special Publication No. 19.
Legal History of Conservation of Oil and Gas. A Symposium. Sections of Mineral Law—American Bar Association.
Report of the Chief of Engineers, U. S. Army, 1938, Part 2.
Treasury Annual Reports 1938, Director of the U. S. Mint.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	$0.75
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	.75
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps William Irelan, Jr.	1.50
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.75
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915: A General report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176, pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.75
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	.75
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	.75

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper	$1.00
Mines and Mineral Resources of Plumas County, 188 pp., paper	.75
Mines and Mineral Resources of Sierra County, 144 pp., paper	.75
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	2.50
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, March, April, **May, June, July, August, September, October, ** November, December, 1922	----
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	.40
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy	.40
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.40
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties	.40
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	.40
**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California, Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	----
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.40
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties	.40
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	----
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island	.40
April, 1927, Mines and Mineral Resources of Amador and Solano Counties	.40
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	----
October, 1927, Mines and Mineral Resources of Mono County	.40
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County	.40
April, 1928, Mines and Mineral Resources of Mariposa County	.40
**July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties	$0.40
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	.40
**April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	----
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties	.40
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties	.40
Chapters of Twenty-sixth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California	.40
**April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	----
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary)	.40
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1931, Preliminary Report of Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative Effects in Concrete	.40
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifera of the Kreyenhagen Shale. Geology of Santa Cruz Island	.40
**July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanite Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	----
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activities in Inyo and Mono Counties in July, 1931	.40
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Carmel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite	.40
**April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining	----
Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed)	.25
July-October. (Ventura.) Report accompanying Geologic Map of Northern Sierra Nevada. Fossil Plants in Auriferous Gravels of the Sierra Nevada. Glacial and Associated Stream Deposits of the Sierra Nevada. Jurassic and Cretaceous Divisions in the Knoxville-Shasta Succession of California. Geology of a Part of the Panamint Range. Economic Report of a Part of the Panamint Range. Acquiring Mining Claims Through Tax Title. The Biennial Report of State Mineralogist	.75

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
Chapters of Report XXIX, 1933 (quarterly: titled 'California Journal of Mines and Geology,' containing the following:	
January-April. Gold Deposits of the Redding and Weaverville Quadrangles. Geologic Formations of the Redding-Weaverville District, Northern California. Geology of Portions of Del Norte and Siskiyou Counties. Applications of Geology to Civil Engineering. The Lakes of California. Discovery of Piedmontite in the Sierra Nevada. Tracing 'Buried River' Channel Deposits by Geomagnetic Methods. Geologic Map of Redding-Weaverville District, showing gold mines and prospects. Geologic Map showing various mines and prospects of part of Del Norte and Siskiyou Counties	$1.00
July-October. Gold Resources of Kern County. Limestone Deposits of the San Francisco Region. Limestone Weathering and Plant Associations of the San Francisco Region. Booming. Death Valley National Monument, California. Placer Mining Districts, Senate Bill 480. Navigable Waters, Assembly Bill 1543	1.00
Chapters of Report XXX, 1934 (quarterly) : titled 'California Journal of Mines and Geology,' containing the following:	
January. Resurrection of Early Surfaces in the Sierra Nevada. Geology and Mineral Resources of Northeastern Madera County. Geology and Mineral Deposits of Laurel and Convict Basins, Southwestern Mono County. Notes on Sampling as Applied to Gold Quartz Deposits	.60
April-July. Elementary Placer Mining in California and Notes on the Milling of Gold Ores	1.00
October. Current Mining Developments in Northern California. Current Mining Activity in Southern California. Geology and Mineral Resources of the Julian District, San Diego County. Geology and Mineral Resources of Elizabeth Lake Quadrangle. Dry Placers of Northern Mojave Desert. Biennial Report of State Mineralogist. Assessment Work Within Withdrawn Areas	.60
Chapters of Report XXI, 1935 (quarterly) : titled 'California Journal of Mines and Geology,' containing the following:	
January. Review of Gold Mining in East-Central, 1934. Current Mining Activities in the San Francisco District with Special Reference to Gold. Geological Investigation of the Clays of Riverside and Orange Counties, Southern California. Information regarding Mining Loans by the Reconstruction Finance Corporation	.60
April. A Geologic Section Across the Southern Peninsular Range of California. New Technique Applicable to the Study of Placers. Grubstake Permits	.60
July. Mines and Mineral Resources of Siskiyou County (with map). Dams for Hydraulic Mining Debris. Leasing System as Applied to Metal Mining. Mine Financing in California. New Laws Make Radical Change in Mining Rights	.60
October. Mines and Mineral Resources of San Luis Obispo County. Mineral Resources of Portions of Monterey and Kings Counties. Mining Activity at Soledad Mountain and Middle Buttes—Mojave District, Kern County. Geology of a Portion of the Perris Block, Southern California. Mineral Resources of a Portion of the Perris Block, Riverside County	.60
Chapters of Report XXXII, 1936 (quarterly) : titled 'California Journal of Mines and Geology,' containing the following:	
January. Gold Mines of Placer County, including Drag-line Dredges. Geologic Report on Borax Lake, California	.60
April. Geology, Mining and Processing of Diatomite at Lompoc, Santa Barbara County. Essentials in Developing and Financing a Prospect into a Mine. Gold-bearing Veins of Meadow Lake District, Nevada County. Semi-Precious Gem Stone Collection in Division Museum	.60
July. Mines and Mineral Resources of Calaveras County. Mining in California by Power Shovel. Assessment Work on Mining Claims Within Withdrawn Areas. Joshua Tree National Monument. Cost	

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price Postpaid
of Producing Quicksilver at a California Mine in 1931-1932. The Age of Mineral Utilization	$0.60
October. Mineral Resources of Lassen and Modoc Counties. Mechanics of Lone Mountain Landslides, San Francisco. Biennial Report of the State Mineralogist, Properties and Industrial Applications of Opaline Silica	.60
Chapters of Report XXXIII, 1937 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Source Data of the Geologic Map of California, January, 1937. The Geology of Quicksilver Ore Deposits. Prospecting for Lode Gold	.60
April. Mineral Resources of Plumas County (with Geologic Map). List of preferred mineral names. New Placer Mining Debris Law	.60
July. Mineral Resources of Los Angeles County (with map showing principal Mines and Oil Fields.) Geology and mineral deposits of the Western San Gabriel Mountains, Los Angeles County	.60
October. Mineral Resources of the Resting Springs Region, Inyo County. Paleozoic Section in the Nopah and Resting Springs Mountains, Inyo County, California. Native Arsenic from Grass Valley, California	.60
Chapters of Report XXXIV, 1938 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Mineral Development and Mining Activity in Southern California during the year 1937. Doing Something About Earthquakes. Gold and Petroleum in California. Gem Minerals of California, Lapidary Art	.60
April. Gold dredging in Shasta, Siskiyou and Trinity Counties; Geology of the Central Santa Monica Mountains; Marketing Mica	.60
July. El Dorado County, Mineral High-Lights of California; Strategic Minerals of California; Cyanide Treatment of Gossan at Mountain Copper Co.; Submarine Canyons off the California Coast	.60
Subscription, $2.00 postpaid in advance (by calendar year only).	
Chapters of State Oil and Gas Supervisor's Report:	
Summary of Operations—California Oil Fields, July, 1918, to March, 1919 (one volume)	Free
Summary of Operations—California Oil Fields. Published monthly, beginning April, 1919:	
**April, **May, **June, **July, **August, **September, **October, **November, **December, 1919	----
**January, **February, **March, **April, **May, **June, **July, **August, **September, **October, **November, **December, 1920	----
January, **February, **March, April, **May, **June, **July, August, **September, **October, **November, **December, 1921	Free
January, February, March, April, May, June, **July, **August, September, **October, **November, December, 1922	Free
January, February, **March, **April, May, **June, **July, August, September, **October, November, **December, 1923	Free
January, February, March, April, May, June, **July, August, September, October, November, December, 1924	Free
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January, February, March, April, May, June, July, August, September, October, November, December, 1926	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1927	Free
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January, February, March, April, May, June, July-August-September, October-November-December, 1929	Free
(Published quarterly beginning July, 1929)	

REPORTS—Continued

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	Price Postpaid
January-February-March, April-May-June, July-August-September, October-November-December, 1930	Free
January-February-March, April-May-June, July-August-September, 1931	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1932	Free
January, February, March, 1933	Free
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October-November-December, 1933	Free
January-February-March, 1934	Free
April-May-June, 1934	Free
July-August-September, 1934	Free
October-November-December, 1934	Free
January-February-March, 1935	Free
April-May-June, 1935	Free

BULLETINS

**Bulletin No. 1. Description of Some Desiccated Human Remains, by Winslow Anderson. 1888, 41 pp., 6 illustrations	----
**Bulletin No. 2. Methods of Mine Timbering, by W. H. Storms. 1894, 58 pp., 75 illustrations	----
**Bulletin No. 3. Gas and Petroleum Yielding Formations of Central Valley of California, by W. L. Watts. 1894, 100 pp., 13 illustrations, 4 maps	----
**Bulletin No. 4. Catalogue of California Fossils, by J. G. Cooper, 1894, 73 pp., 67 illustrations. (Part I was published in the Seventh Annual Report of the State Mineralogist, 1887)	----
**Bulletin No. 5. The Cyanide Process, 1894, by Dr. A. Scheidel. 140 pp., 46 illustrations	----
**Bulletin No. 6. California Gold Mill Practices, 1895, by E. B. Preston, 85 pp., 46 illustrations	----
**Bulletin No. 7. Mineral Production of California, by Counties, for the year 1894, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 8. Mineral Production of California, by Counties, for the year 1895, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 9. Mine Drainage, Pumps, etc., by Hans C. Behr. 1896, 210 pp., 206 illustrations	----
**Bulletin No. 10. A Bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by Anthony W. Vogdes. 1896, 121 pp.	----
**Bulletin No. 11. Oil and Gas Yielding Formations of Los Angeles, Ventura and Santa Barbara Counties, by W. L. Watts. 1897, 94 pp., 6 maps, 31 illustrations	----
**Bulletin No. 12. Mineral Production of California, by Counties, for 1896, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 13. Mineral Production of California, by Counties, for 1897, by Charles G. Yale. Tabulated sheet	----
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Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D. NORDENHOLT, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

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QUARTERLY CHAPTER
OF
STATE MINERALOGIST'S REPORT XXXV

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

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WILLOWS
OROVILLE
DOWNIEVILLE
UKIAH
LAKEPORT
COLUSA
YUBA CY
MARYSVILLE
NEVADA CY
AUBURN
WOODLAND
SACRAMENTO
PLACERVILLE
MARKLEEVILLE
SANTA ROSA
NAPA
JACKSON
BRIDGEPORT
SAN RAFAEL
MARTINEZ
SAN ANDREAS
SONORA
STOCKTON
OAKLAND
MODESTO
REDWOOD CY
SAN JOSE
MARIPOSA
MERCED
MADERA
HOLLISTER
SALINAS
FRESNO
INDEPENDENCE
VISALIA
HANFORD
PORTERVILLE
BAKERSFIELD
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
SANTA ANA
SAN DIEGO
ELCENTRO
DEATH VALLEY
·LEGEND·
Mining Division Boundaries.
Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).
2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).
3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

CHAS. VOLNEY AVERILL, Mining Engineer

MINERAL RESOURCES OF SHASTA COUNTY

GEOGRAPHY.

Shasta County lies at the northern end of the Great Central Valley of California. It has an area of 3858 square miles and in 1930 had a population of 13,925 persons, most of whom live in the valley regions contiguous to Sacramento River. Population has now (1939) increased by roughly 5000 persons largely on account of the construction of the Shasta dam at a point on the Sacramento River 10 miles north of Redding. The river leaves its mountainous canyon near Redding and south of there flows through an open, rolling county devoted to farming. The mineral deposits are confined to the western half of the county. Most of the eastern half is covered by volcanic rocks. To the west and northwest ranges of the Klamath Mountains separate Shasta from Trinity and Siskiyou counties. Lassen, Modoc and eastern Siskiyou counties on the north and east, as well as eastern Shasta, are covered by comparatively recent volcanic flows and the elevation of this lava field rises steadily as one travels eastward until the high mountain peaks are reached.

TRANSPORTATION.

Redding, the county seat, is 175 miles north of Sacramento, and is the principal railroad and supply point for Shasta and Trinity counties. The Pacific Highway, an excellent paved road, traverses the valley, connecting California and Oregon cities. Branching from it at Redding are paved roads to Alturas toward the east, and Weaverville toward the west. The latter road continues as an oiled road to Eureka on easy grades. This portion is gradually being widened and straightened. From these highways good branch roads lead to all the mining districts of the county, and due to the generally mild climate are passable throughout the year for automobiles. The Oregon line of the Southern Pacific Railroad gives the county rail connection with California points to the south, and with Oregon and other states to the north and northeast. It follows the canyon of Sacramento River north of Redding but it must now be removed from the canyon for a distance of 36 miles because of water that will form the reservoir behind Shasta dam. Short railroad lines from Anderson to Bella Vista, from Keswick to Iron Mountain, and from Pit to Bully Hill are no longer in operation.

CLIMATE.

A rainy season from October to May is followed by a warm, dry summer. Total precipitation at Redding averages about 37 inches. In some winters it falls entirely as rain, in others a foot or two of snow lies on the ground for a few days. In the mountains to the north, both the total precipitation and the amount that falls as snow increase very rapidly. In the Kennett area, where the Shasta dam is being

built, total precipitation during the winter 1937-1938 was considerably more than 100 inches. It is usually twice as much in this area as at Redding. Maximum summer temperature at Redding is 113° F.

AGRICULTURE.

Agricultural production is roughly $1,500,000 per year. Beef cattle, hogs, lambs, milk and butter-fat are the principal products. Other products are wool, poultry, eggs, wheat, barley, oats, sorghum, potatoes, vegetables, grapes, berries, strawberry plants, prunes, peaches, apricots, apples, bees and honey.

TIMBER.

Both the eastern and western parts of the county are covered by good sized timber, as is also part of the upper canyon of the Sacramento, although the last named section has been largely cut over because of its accessibility. The lowland country near the river, and the copper mining districts support only scrub growth. Northeastern Shasta County, from the vicinity of Round Mountain northeastward, and contiguous to the Alturas highway, has one of the finest stands of virgin timber in the state. Several small lumber mills are operated in the county, and some very large ones just beyond its borders at Weed, McCloud and Westwood.

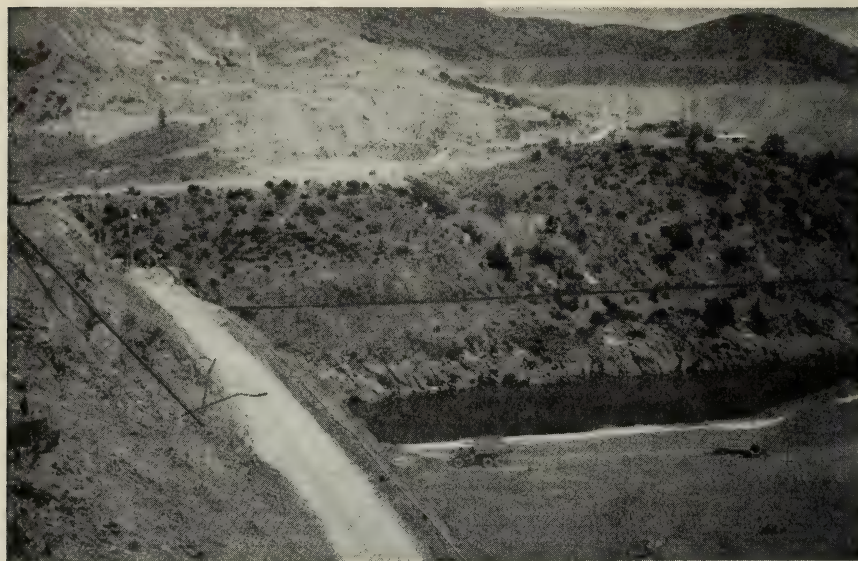
POWER.

The vast lava beds of northeastern California form a remarkable underground reservoir from which Pit River draws a nearly uniform volume of water throughout the year, with less seasonal variation of flow than in any other important stream in the state. The river also has sufficient grade, and numerous sites in its canyon are favorable for the building of high dams, so that it is peculiarly attractive as a source of hydroelectric power. Pacific Gas and Electric Company operates Pit 1 power house with a capacity of 65,000 kw. and Pit 3 with a capacity of 82,500 kw. The company has seven other power houses on smaller streams of the county, two of which are automatic. The range in capacity is from 1500 kw. to 15,000 kw. High-tension lines on steel towers transmit electricity under a potential of 220,000 volts, for a distance of 205 miles to the Vaca-Dixon station, where it is stepped down to a voltage of 110,000 for distribution to cities around San Francisco Bay. This power is also available to the mining districts of Shasta County.

Large consumers of primary industrial power, such as the larger mines and dredges, are on a schedule which carries a minimum energy charge of four mills per kilowatt-hour. When the demand charge is added, however, the average cost per kilowatt-hour is likely to be nearer half a cent. Adjustments are made for taking power at a higher voltage than 2200, for peak load, for off peak demand, for power factor, and for variations in the price of fuel-oil. Details are available on Schedule P-30 issued in printed form by the Pacific Gas and Electric Company.

Whether power generated at Shasta dam, now under construction, will be available at lower rates remains to be seen. If the rates are

substantially lower, no doubt interest in electric smelting will be revived. The most likely application would appear to hinge on the possible development of a sufficient tonnage of highgrade copper concentrate carrying gold to support an electric smelter. A great advantage of this method is that the sulphur dioxide evolved can be readily converted into sulphuric acid, and damage from smelter fumes, which has been extensive in the past, would be avoided. The method is probably too expensive for the heavy pyritic ores, and would apply only to concentrates made from siliceous ores. Another possibility is the smelting of iron ore for pig iron and ferro-alloys. This is discussed in further detail on a later page, under the heading 'Iron.'



Excavation at Shasta dam-site in May, 1939. Trucks in foreground are of 25 cu. yd. capacity. (Photo by Walter W. Bradley.)

GEOLOGY.

Shasta County contains a rather unusually complete series of geologic formations. Starting in the southwestern part of the county, and traveling northeasterly, one would cross very old schists, of unknown age, possibly Archean; a series of pre-Devonian lava flows (the Copley meta-andesite); Devonian, Carboniferous, Permian, Triassic, and Jurassic sediments. In the southern part of the county, or the northern end of the Sacramento Valley, which was once an arm of the sea, are Cretaceous, Tertiary, and Quaternary sediments. The eastern half of the county is covered by a series of Tertiary and Quaternary lava flows. Formations older than the Cretaceous are intruded by a series of igneous rocks ranging from serpentine to granodiorite.[1]

[1] Jenkins, O. P., Geologic Map of California: Calif. State Division of Mines, 1938.
Hinds, N. E. A., Geologic formations of the Redding-Weaverville districts, northern California: Calif. State Mineralogist's Rept., vol. 29, pp. 76-122, 1933.
Diller, J. S., U. S. Geol. Survey Geol. Atlas, Redding folio (no. 138), 1906.

Lassen Peak, the only active volcano in the continental United States, is in the southeastern corner of Shasta County. The last eruptions[1] (1914-1917) began by a slight explosion within the old crater on the summit of Lassen Peak. Only a small mass of material was erupted, but activity continued steadily for some time. During the first phase the explosive eruptions carried out rock fragments and dust only. The size of the crater increased with each eruption. The second phase, which was extrusive, included also an eruption of lava, which formed a lid on the volcano and overflowed to the west and northeast.

In the beginning the new crater was confined to the loose material filling the old crater, but later it reached the solid rock of the old crater rim, and finally after more than 150 eruptions it attained, near the end of March, 1915, a diameter of about 700 to 1,000 feet.

At about this time, the old crater having been thoroughly cleaned out by explosive eruptions and the overlying lava largely removed, the magma began to rise in the volcanic conduit and initiated the second or extrusive stage of the volcanic activity. The hot magma, apparently more or less viscous in the volcanic conduit, gradually was forced upward by the pressure of magma or gas from beneath until it reached the surface as new lava, and as a lava table filled not only the new but also the old crater, so as to form a lid on the volcano. The lava issuing from the edge of the lid through a notch in the old rim passed down the west slope of Lassen Peak about 1,000 feet, also over the northeast rim.

On the night of May 19 and on the afternoon of May 22, 1915, there were violent eruptions. A mushroom-shaped cloud was formed at a height of about four miles above the summit of the mountain and afforded a magnificent spectacle as seen from the Sacramento Valley.

Although the extrusion of the new lava, with the formation of the lava lid, was the main feature of the great eruptions in May, 1915, it was far surpassed in interest and wonder by the remarkable horizontal eruptions of the hot blasts that devastated Lost and Hat Creeks. It appears that the body of superheated gases which accumulated beneath the lid, forcing it up, escaped from under the edge with terrific force down the deep snow-covered northeast slope of Lassen Peak toward Lost and Hat Creeks. The snow was instantly converted into water, and the mighty onrush of water and blast of hot gases swept everything before them for more than 10 miles along Lost Creek, forming a devastated belt from a few hundred yards to a mile in width. Trees three feet in diameter were broken off or uprooted and the country scoured as by a mighty sand blast. The fine green leaves of the pine trees left standing along the borders of the blast were killed by the heat and turned brown. Locally, on favorable slopes, the heat was so great that the green leaves were charred; not only those of the pine but also those of the manzanita, several acres of which, at a distance, had the general appearance of an area swept by a forest fire. It was reported by the forest ranger in the vicinity that two

[1] Diller, J. S., Volcanic history of Lassen Peak; quoted in booklet of U. S. National Park Service, Lassen Volcanic National Park, California.

fires were actually kindled by the eruption. The effect of this blast is well shown by a series of three photographs published in State Mineralogist's Report XXII.[1]

Additional short descriptions of local geology will be found on later pages accompanying articles on individual substances such as barite, copper, and gold.

MINERAL RESOURCES.

Recent production has been largely gold from the cyanide mill of The Mountain Copper Company, Ltd., treating a gossan-ore, and placer-gold from dragline dredging done by several companies operating southwest of Redding. The Mountain Copper Co. produces also several hundred tons per day of pyrite for the manufacture of sulphuric acid. The French Gulch District is again a regular producer with two new mills producing jig-concentrate, which is treated by amalgamation, and flotation-concentrate which is shipped to smelters. A considerable tonnage of barite has been produced from the deposit on the top of the mountain range east of Castella by Glidden Company of California, for the manufacture of lithopone, a white pigment.

Past production of $110,000,000 in copper by Shasta County is notable, but the smelters have all been dismantled, and production of copper is very small. A little copper is produced from the residues left from the manufacture of sulphuric acid from pyrite; also a little from mine-water. Exploration has been resumed in the Mammoth mine near Kennett by United States Smelting Refining and Mining Company, and some ore has been discovered. However, this ore seems to be more valuable for its zinc content than for its copper content.

Large deposits of diatomite, iron, and lignite occur in the county. There has also been some commercial production of each of the following: asbestos, cadmium, chromite, clays, coal (lignite), lead, lime and limestone, manganese, mineral water, molybdenum, platinum, silver, talc, and zinc. These are described in alphabetical order on the following pages. Production since 1880 is shown on the accompanying table.

ASBESTOS.

Deposits of asbestos have been found from three to seven miles north and northwest of Sims, in Townships 37 and 38 north, Ranges 4 and 5 West in the northwestern part of the county. Apparently the asbestos that has attracted the most attention is of the amphibole variety. Large specimens of this are readily obtainable, but when an attempt is made to separate the fibers, it is found that they are too brittle to stand any handling. Hence this amphibole variety has little commercial value. The valuable variety of asbestos is chrysotile, from which fibers are readily separated that can be spun into a strong, flexible thread with the fingers. Specimens of this variety showing fibers from a quarter of an inch to an inch long have been brought in from several points in the high mountains of this region, but so far as is known no roads have been built to any deposits of this variety.

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[1] Logan, C. A., Shasta County: Calif. State Mineralogist's Report XXII, pp. 122, 124, 126, 1926.

MINERAL PRODUCTION OF SHASTA COUNTY, 1880-1938

Year	Brick		Chromite		Copper		Gold, value	Lime		Limestone		Mineral water		Pyrites		Silver, value	Miscellaneous stone[3], value	Miscellaneous and unapportioned		
	M	Value	Tons	Value	Pounds	Value		Barrels	Value	Tons	Value	Gallons	Value	Tons	Value			Amount	Value	Substance
1880							$140,455									$117,007				
1881							350,000									85,000				
1882							300,000									80,000				
1883							210,000									20,000				
1884							320,000									30,000				
1885							417,004									9 223				
1886							699,508									10,047				
1887							627,681									40,204				
1888							600,000									50,000				
1889							415,631									5,396				
1890							420,530									7,279				
1891							554 063									7,432				
1892							574,833									7,977				
1893							500,407									8,577				
1894			1,200	$16,800			617,436					150,000	$75,000			5,032		200 tons	$1,500	Iron ore
1895			80	1,120			718,696									28,417				
1896	300	$1,500			1,847,087	$184,708	599,209	2,310	$2,541							24,233	$1,400			
1897	1,200	7,200			13,592,610	1,535,966	569,071	2,100	2,100	9,000	$13,500					96,869				
1898	1,200	7,200			21,442,000	2,465,830	860,180	2,500	3,750			3,000	2,000			171,768				
1899	2,000	14,000			21,835,863	3,565,023	873,719	8,000	10,000	250	375	5,000	1,850			196,213	375	100 sq'rs	800	Slate
1900	2,000	12,000	140	1,400	25,736,473	4,166,735	733,467	17,850	17,850	1,150	1,150	9,640	5,784			635,640				
1901	3,000	12,000	130	1,950	30,990,781	4,881,046	927,975	21,600	12,960			26,295	7,644			801,994	2,000			
1902	2,450	12,250	315	4,275	21,515,887	2,496,731	878,706	18,500	12,500	3,500	3,600	26,295	7,645	3,202	$7,005	306 887				
1903	3,500	17,500	150	2,250	16,453,409	2,171,497	771,242	27,000	10,800	5,400	5,400	40,000	12,000	2,500	5 500	203,091	1,500			
1904	3,000	15,000	98	1,470	26,438,145	3,439,974	1,031,429	18,000	10,500							399,660			47,723	Unapportioned, 1900-1909.
1905	3,500	14,000	20	300	10,830,865	1,688,614	684,952	10,700	8,000	3,600	3,600	80,000	12,000			167,548				
1906	4,400	22,000	80	1,200	22,477,304	4,338 121	819,144	12,860	8,040	27,000	32,060			32 689	89,895	434,483				
1907	4,500	33,000	260	5,200	27,844 364	5,568 873	791 997	29 222	31,900	30,761	30,761			65,788	197,364	370,211		400 tons	400	Iron ore.
1908	2,000	12,000	280	5,600	34,878,677	4,642,976	1,131,832	11 818	9,100	80,000	80,000	100,000	20,000	93,677	539,553	517,596	25,000			
1909	3,500	23,500	205	3,517	58,665,447	7,581,115	1,600,480	8,650	8,000	129,560	134 595	100,000	20,000	449,762	1,349,286	735,460	4,688	108 tons	174	Iron ore
1910	2,425	17,548	680	9,155	44,947,950	5,725,469	1,533,728	16,616	14,114	117,109	117,083	40,000	10,000	31,683	126,692	648,905		579 tons 1,859 lbs.	900 83	Iron ore. Lead.
1911	2,825	20,094	875	13,697	29,539,913	3,692,489	[1]1,059,881	13,271	10,164	67,924	65,253	25,000	6,250	47,885	151,602	386,091		881 lbs.	40	Lead
1912	1,697	10,195	1,000	8,000	25,249,892	4,166,232	986,803	6,529	3,548	58,022	45,575	23,225	5,646	62,605	174,402	425,382				
1913	360	4,330	280	2,800	27,686,436	4,291,708	1,208,870	8,595	7,030	41,346	35,616	30,000	6,850	72,071	194,409	448,031		47 tons 19,070 lbs.	1,175 839 10,686	Asbestos Lead. Other minerals.
1914	1,594	10,223	867	4,884	25,122,766	3,341,328	1,101,202	8,657	5,163	36,997	30,026	30,000	6,850	69,438	195 362	346,706	125	1,436 tons 21,565 lbs.	5,128 841	Iron ore Lead
1915	1,836	11,550	1,757	17,570	30,828,917	5,305,060	1,120,848	[2]		44,953	10,945	12,000	1,800	[2]		450,566	1,418	180,936 lbs. 8,378,401 lbs	8,504 1,038,922 253 950	Lead Zinc Iron ore, pyrites, lime.
1916	[2]		12 425	181,225	39,437,196	9,701,550	936,885	[2]		[2]				[2]		1,115,471	800	478,560 lbs. 9,484,800 lbs	33,021 57,303 1,270,963 342,290	Lead Lime and limestone Zinc Asbestos, brick, iron ore, manganese, mineral water, platinum, pyrites, silica
1917	[2]		3,116	68,479	28,000,990	7,640,727	775,125	[2]		[2]				[2]		520,703	800	8,725 lbs 14 ozs 8,281,516 lbs	750 78,101 1,100 844,715 308,369	Lead Lime and limestone. Platinum Zinc Cadmium, brick, iron ore, mineral water, molybdenum, pyrites, silica
1918	[2]		1,423	70,214	25,294 590	6,247,764	543,509			45,671	72,410			[2]		420,410	7,000	492,565 lbs 35 ozs. 3,045,692 lbs	34,972 2,709 277,158 422,525	Lead Platinum Zinc Cadmium, brick, iron ore, lime, mineral water, molybdenum, pyrites
1919	[2]				8,673,342	1,613,242	378,283	[2]		[2]		[2]		138 046	[illegible]	165,802	31,750	 121 fine ozs	29,100 21,075 40,153	Lime and limestone Platinum Barytes, brick, iron ore, lead, mineral water, zinc
1920	[2]				810,843	149,195	312,001							145,399	[illegible]	36,563	32,650	64,400 lbs 158 fine ozs	5,152 27,004 69,743	Lead Platinum. Asbestos, brick, iron ore, lime, limestone, zinc
1921					437,593	56,449	267,681	[2]		[2]						5,581	31 945	219 fine ozs	26,817 452 589	Platinum Asbestos, barytes, iron ore, lead, pyrites, zinc.
1922					1,827,875	246,763	393,034							[2]		26,101	65,525	496 fine ozs	57,458 723,910	Platinum Asbestos, barytes, iron ore, lead pyrites, zinc
1923					3,437,963	505,381	359,487			[2]						47,706	86,500	328 115 lbs 299 fine ozs	22,968 43,326 498,019	Lead. Platinum Asbestos, barytes, iron ore, lime, limestone, pyrites.
1924					21,109,958	2,765,405	346,622			28,097	36 480			[2]		343,102	587,637	6,615 lbs 27 fine ozs.	529 3,361 671,228	Lead Platinum Asbestos, coal, diatomaceous earth, iron ore, pyrites, zinc.
1925					14,565,967	2,068,367	235,013			24,395	28,480			[2]		208,818	349,617	647,886 lbs. 8 fine ozs 11,090,430 lbs.	56,366 725 842,873 510,190	Lead. Platinum. Zinc. Chromite, diatomaceous earth, iron ore, pyrite, talc
1926					5,113,114	715,856	132 306							[2]		110,719	162,355	15,584 lbs. 28 fine ozs. 17,757,000 lbs	1,247 3,034 1,331,775 428,272	Lead. Platinum. Zinc Coal, diatomaceous earth, iron ore, limestone, pyrite, talc
1927					4 524,506	592,713	191,000							[2]		70,201	134,678	1,780 lbs 25 fine ozs.	112 2,552 957,822	Lead Platinum. Diatomaceous earth, limestone, pyrite, talc, zinc
1928			[2]		3 049,910	439,194	113,194							[2]		39,431	137,034	4,400 lbs	255 385,683	Lead. Chromite, coal, diatomite, platinum, pyrite
1929					6 966,098	1,067,643	84,089							[2]		31,048	247,351		315,475	Asbestos, chromite, diatomite, platinum, pyrite
1930					3,962 383	515,110	226,214							[2]		5,442	228 778		135,602	Platinum, pyrite
1931					309,314	28 148	431,165							[2]		2,816	154,103		149,794	Barite, granite, lead, platinum, pyrite.
1932					295,981	18,647	529,935									3,973	58,306		125	Unapportioned
1933					885,108	54,727	618,290							[2]		6,884	233,110	14,883 lbs	551 199,873	Lead Platinum, pyrite.
1934					388,775	31,102	718,583							[2]		16,816	147,070		231,609	Lead, platinum, pyrite
1935					6,178	513	962 448									23,805	72,850		290,646	Chromite, lead, pyrite
1936							1,304 590									22 715	97,265		275,332	Copper, lead, platinum, pyrite
1937					88,985	10,767	1,773,275									30 786	108,039		276,556	
1938							1,439,620									18,599	80,520		252,968	Granite (volcanic rock), platinum, pyrite, sandstone, lead, copper.
Totals	47,287	$277,090	25,391	$421,106	686,220 855	$109,924,780	$39,731,337	244,778	$188,060	711,064	$715,390	700,455	$201,319	1,205,645	$4,003,708	$11,655,877	$3,092,249		$14,387,530	

[1] Dredge production included under Stanislaus County.
[2] See under 'Unapportioned.'
[3] Includes crushed rock, rubble, rip-rap, sand and gravel

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Mill of Stock Asbestos Mining Co.

Anaconda Prospect is in Sec. 6, T. 37 N., R. 4 W., four miles north of Sims.

D. E. Miles Prospect is in Sec. 36, T. 38 N., R. 5 W., five miles north of Sims.

James W. Hanegan, Box 1026, Redding, has brought in specimens of chrysotile asbestos showing fibers half an inch long from a point near Highland Lake, Sec. 12, T. 37 N., R. 6 W.

Stock Asbestos Mining Company, Mrs. Sarah L. Stock, President, 1200 E. Ocean Boulevard, Long Beach, holds 13 mining claims and hundreds of acres of patented land in Sec. 1, 2, 3, 4, T. 37 N., R. 5 W., and Sec. 33, 34, T. 38 N., R. 5 W. The land is assessed to Mrs. Stock, who leases it to the company. In 1937, a small mill was constructed at a point on Mears Creek with an elevation of 3500 ft. It is reached from the Pacific Highway by two miles of steep mountain road. The mill contains a hammer-mill and several blowers and cyclones for separating various products with air-currents. Power is furnished by a gasoline engine. Construction was under the supervision of George Anderson, Hazel Creek (P. O.), Shasta County.

The few tons of amphibole asbestos that were run through the plant came from an open cut 10 ft. long, with a 10-ft. face, at a point $3\frac{1}{2}$ miles farther up Mears Creek. It is reached by a new road, which is very steep and rough; and the last quarter of a mile is trail. The plant was idle in 1938.

At a point 2000 ft. still higher in elevation, chrysotile asbestos is said to be exposed in prospect-cuts. Samples at the mill show cross-fiber about an inch long. An additional three miles of road will be needed to reach these prospect-cuts. References to former reports on this property are contained in the accompanying table of mines.

BARITE.

Afterthought comprising four locations, Afterthought 1, 2, 3 & 4, in Sec. 2, T. 34 N., R. 4 W., is held by George Dean and Eli Popejoy of Redding. It is 20 miles north of Redding, 17 miles highway to the Baird fish hatchery, then a mile of mountain road and two miles of trail. The McCloud River is a mile east.

Barite is found in fissure veins in a basic-appearing holocrystalline rock of fine granitic grain, probably gabbro. In a cut 15 ft. long, a vein of barite 2 ft. to 3 ft. wide is exposed. The greatest depth of the cut is 6 ft. At a distance of a few feet from this vein, in the face of the cut, a parallel vein with a width of a few inches is exposed. This is seen to widen to the southwest, and a width of 3 ft. is exposed in a second cut 20 ft. to the southwest. The strike is N. 50° E. and the dip is 80° NW. At a point 200 ft. northeast of the cut first mentioned, a cut 15 ft. long exposes a width of 5 ft. to 6 ft. of barite. An adit, 20 ft. long, from the face to this cut is entirely in the footwall. Two small cuts, 30 ft. northeast of this adit, both expose widths of a few feet of barite, and indicate a possible branching of the vein. At a point 1000 ft. to the northeast of the cut first mentioned above, the barite outcrops with a width of at least 6 ft. No work has been done here. In the 1000-ft. distance the barite outcrops at intervals. It appears to pinch and swell like a quartz vein. To the east other croppings are found, probably on a different vein. A cut exposes a maximum width of 8 ft. of barite striking east and west. The barite here is a very white, coarsely crystalline variety, apparently quite pure. The owners state that it runs 97% $BaSO_4$.

William Greenwood holds some claims for barite to the north of this property in Sec. 35, T. 35 N., R. 4 W. An interval of 250 ft. exists between this group and the Afterthought. A width of 8 ft. of barite is exposed here also.

Barite No. 1 and No. 2 claims are in Sec. 28(?), T. 29 N., R. 9 W., on Beegum Creek near Platina, which is 41 miles by road southwest of Redding. A width of a few feet of barite is exposed at a point about two miles by trail from Platina. A little witherite (barium carbonate) has been found here, but apparently it is not in commercial quantity. Additional development work is needed on the deposit to determine whether construction of a road to it is justified. At the time that the deposit was visited, only a small open cut in the steep side of the canyon of Beegum Creek had been made.

Bidwell ranch is just south of the town of Montgomery Creek on the Redding-Alturas highway. Elmer Bidwell has found prospects of barite in lens or vein-form at a point half a mile north of the ranch on Willow Creek, in Sec. 2, T. 34 N., R. 1 W. Prospect-cuts a few feet deep have been made. The barite, being only about two feet wide, does not appear to be of commercial importance under present conditions.

The Glidden Company, c/o E. L. Ralston, Box 538, Redding, owns the barite deposit formerly called the *Loftus* in Sec. 18, 19, T. 38 N., R. 3 W., on the ridge east of Castella. Three claims known as Barite No. 1, Barite No. 3, and Marion have been patented under Mineral

Survey 5906. Land formerly belonging to the Southern Pacific Land Co. has been purchased to take in another exposure 1500 ft. to the southeast. The barite is on the very top of the ridge on the line between sections 18 and 19, at an elevation of nearly 5000 ft. or 3000 ft. above the railroad tracks at Castella.

A seven-mile road built on a grade of 10% has been completed from Castella to the deposit, at a cost of $15,000. Several thousand tons of the barite have been mined from surface-pits with a gasoline power shovel of ½-cu. yd. size. The ore was loaded on six Ford trucks of 1½-cu. yd size, with steel dump-bodies, which carried 3½ tons to 4 tons per load, and was then dumped into gondola cars on the railroad at Castella. Cost per ton of producing this barite was as follows: mining, $0.58; trucking (contracted), $1.12; freight to San Francisco, $3.20; road charge (based on a total production of 15,000 tons), $1.00. Shipments varied in grade from 88% to 96% $BaSO_4$, and the average for the first 6500 tons was nearly 93%. Much of the barite is light to dark gray in color, and is also stained to some extent by oxides of iron. It was used for the manufacture of lithopone, a white pigment. In this process the barite is purified by calcining, then dissolving and filtering.

The barite is very fine in grain and is stratified, the strata being practically horizontal. A prospect tunnel below the deposit exposes slate with the same horizontal attitude. While the slate is the predominant formation in the vicinity, some lenses of limestone are present; also abundant sandy strata in the slate. Thin beds of very fine-grained sand, a fraction of an inch thick, are found in a few places interstratified with the barite. A cut just below a lower deposit, which has not yet been mined, indicates that fine-grained sandstone underlies this deposit. The hypothesis is suggested that this barite was deposited by a spring carrying barium chloride issuing from a vent in the ocean-floor, and that the barium sulphate was precipitated by soluble sulphates contained in the sea-water, and was interstratified to a limited extent with the marine sediments. Study of thin sections of the barite under the microscope might shed further light on this point. The sediments are probably either Devonian or Carboniferous. A careful search of the limestone in the vicinity would probably result in the discovery of fossils that could be identified.

CADMIUM.

Cadmium occurs as greenokite in the copper-zinc ores of Shasta County.[1] Greenokite is rare, but is found occasionally as a lemon-yellow coating with resinous luster, on zincblende.

The only recorded production of cadmium from California was from the electrolytic zinc plant of the Mammoth Copper Company during 1917-18, where several thousand pounds of cadmium metal was produced. Cadmium sulphide is used for a yellow paint pigment and for coloring glass. Cadmium is used in making alloys of low-melting point, in bronze wire, and in plating iron and steel articles to prevent rust. No production is being made from Shasta County at this time.

[1] Pabst, Adolf, Minerals of California: California Div. Mines Bull. 113, p. 61, 1938.

CHROMITE.

In the northwestern corner of Shasta County is an area in which serpentine and basic igneous rocks partly altered to serpentine occur abundantly. The area extends northeasterly from Lamoine to a point beyond Dunsmuir, and northerly into Trinity and Siskiyou counties.[1] It appears to lie entirely west of Sacramento River. Some of the largest lenses of chromite so far developed in the United States have been found in this area. Since the end of the war in 1918, very little chromite has been produced from Shasta County and only those properties are listed here on which developments of interest have been noted recently. For other properties reference should be made to Bulletin 76 [2] of this division. The locations are listed in the accompanying table of mines.

Little Castle Creek Mine is in Sec. 2, T. 38 N., R. 4 W., about three miles south of west from Dunsmuir, on the ridge on the south side of Little Castle Creek, and on the Shasta-Siskiyou county line. L. H. Brown of Dunsmuir worked the property for a number of years earlier than 1915, and then sold to California Chrome Company. The largest single lens or segregation so far found in California has been mined here. The records of this division show a production of approximately 15,000 tons to the end of 1916. Brown estimates the total at 20,000 tons.

L. H. Brown and M. M. Brown of Dunsmuir have again acquired this property, a patented tract of 80 acres, and have started to develop it further. They state that a small part of the original lens still remains in place below the lowest adit-level, and that they will do work designed to develop other lenses, evidence of the existence of which they find on the surface.

Union Forest Queen is in Sec. 22, T. 37 N., R. 5 W., four miles west of Gibson. Six claims are now held by Antone Orsini, 1409 Olive Street, Redding. The property was a producer during the war under the name *Forest Queen*, and a few tons of ore mined at that time have recently been shipped. About 1000 tons of ore averaging 43% Cr_2O_3 and 5% to 6% SiO_2 are reported to have been produced.

CLAY.

Clay suitable for making common brick occurs abundantly in the county in the flood plain of Sacramento River south of Redding, and along numerous other streams more remote from the railroad. A brick plant was formerly operated at Anderson, but it has been idle for many years, and no clay products have been made in the county since it shut down. The large brick kiln and stack still stand. The capacity was 40,000 brick in seven hours. Clay was produced on the property from a bed 15 feet thick. Other deposits of clay are listed in the accompanying table of mines.

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[1] Averill, C. V., Preliminary report on economic geology of the Shasta Quadrangle (with geologic map): California State Mineralogist's Report XXVII, pp. 3-65, 1931.

[2] Bradley, W. W.; Huguenin, Emile; Logan, C. A.; Tucker, W. B.; Waring, C. A.; Manganese and chromium in California: California State Min. Bur. Bull. 76, 1918.

COAL.

That the lignite prospects of central Shasta County were known in 1863, and were being prospected as early as 1874, is shown by W. A. Goodyear's mention of the district in the Seventh Report of the State Mineralogist, pages 149 and 150. He described work that had been done apparently near the recent work on the Luce property, and gave a section of the coal bed. In 1876, when he again visited the place, work had been abandoned. He mentioned another tunnel, which had been driven nearby for a length of 400 to 500 feet. He also alluded to other coal outcrops which he noticed in Sec. 3, 7, 8, 21, T. 33 N., R. 1 W., in Sec. 12, T. 33 N., R. 2 W., and elsewhere, none of which had been found up to that time to contain marketable coal. In the same volume, Adolph H. Weber briefly described other coal prospects.

In central Shasta County the sedimentary rocks of the Chico (Cretaceous) and Eocene are overlain by the later Tuscan Tuff (late Tertiary) and still later basalt and cobbles. The lignite occurs mostly in the Eocene, which is a series of rather soft, slightly consolidated sandstone, shale and conglomerate beds. The overlying basalt and cobble layer is about 30 feet thick in many places. At the Luce coal workings, where the beds appear to be undisturbed, the coal seams dip north and east at an angle of seven degrees. The roof of the coal is soft sandstone and shale, and the floor is shale. Diller in the Redding Folio of the U. S. Geological Survey describes the Ione formation (a Tertiary formation which has been redefined [1]) and alludes to the difficulty of determining whether some of the beds lacking distinctive fossils are Ione or Cretaceous. In the Lassen Peak Folio, he places some of the coal seams of this region in the Chico (Cretaceous). As far as can be learned, lignite recently developed is in the Eocene. During the time when this formation was deposited, apparently an arm of the sea filled the Sacramento Valley, extending northeast through the region where the lignite occurs, but the water in this region is supposed to have been relatively fresh. Periods favorable to the deposition of lignitic material appear to have been interrupted by shorter periods when mud and sand were deposited, and the result is a series of beds of lignite alternating with thin partings of shale, which are too thin to be sorted out, but which lower the quality of the coal by the introduction of waste.

The lignite is mostly black and lustrous when first mined, and in physical appearance seems distinctly older than the brown lignite of the typical Ione beds, near the town of Ione, Amador County.[2] While the Ione lignite often shows woody structures and even the bark of trees, and cracks and crumbles in a short time when exposed and dried, the best seams of lignite near Oak Run do not show these characteristics so distinctly, although it probably would not stand transportation well. In chemical analysis, there is little difference between them, both being low in fixed carbon and high in volatile matter. The ash content of the Ione lignite is slightly lower if published analyses are accurate, but it carries more water than the Oak Run lignite.

[1] Hinds, N. E. A., Geologic formations of the Redding-Weaverville districts, northern California: State Mineralogist's Report XXIX, p. 115, 1933.

[2] Logan, C. A., Shasta County: California State Mineralogist's Report XXII, p. 133, 1926.

The last extensive work on this coal or lignite was done by persons who were interested in its possibilities for the manufacture of gas. In 1929, this interest ceased, apparently due to the extensive commercial development of natural gas at Kettleman Hills, and no work has been done on the coal since that time. Recent commercial development of natural gas at Marysville Buttes, and the probability of similar development near Willows are likely to still further retard production of Shasta County coal. However, the coal is a valuable reserve supply of fuel, and a description of the latest work done is given here as a matter of record. One point that would seem to deserve further investigation is the possibility of using this coal as powdered fuel for cement kilns. Limestone is abundant in the region, and it seems possible that the ash of the coal might furnish part of the aluminous material for the cement. So far as is known, no chemical analyses of the ash have been made to determine whether or not it is suitable for this purpose. The Kosk Creek deposit is described because it has not before been visited by a representative of this division, and the Mount Shasta Coal Company because of new development work. For descriptions of other deposits, reference should be made to State Mineralogist's Report XXII. Their locations are listed in the accompanying table of mines.

Kosk Creek Coal Deposit is in Sec. 9, 10, 14, 16, 22, T. 38 N., R. 1 E., at an elevation of 2500 to 4500 feet, eight miles by road and then four miles by trail south of Bartle. Jerry Jones, 1447 Magnolia Street, Chico, obtained leases from the United States Government on 2158 acres of this land and employed five men in prospecting it during the summer seasons for four or five years. The lower workings on Kosk Creek show two seams of coal each about four feet thick but with seams of shale or clay every few inches. Between the two main beds of coal is 17 ft. of very fine-grained bluish sandstone. The widest seam of coal free from shale or clay is about one foot in width. The strike is easterly and westerly and the dip 5° north. An adit with portal at creek level, starting in the lower seam, exposes part of the upper seam in the face, at a distance of 80 ft. Apparently a small amount of faulting accounts for the tunnel striking the upper seam at a distance less than that indicated by the dip. Upper workings on Coal Creek consist of an adit and a flat incline following the coal on its dip for a distance of 130 ft. The direction is N. 66° E. Another exposure of this seam or a parallel one is seen a few hundred yards above at the falls on Coal Creek. A seam of clay or shale occurs every few inches in these exposures also, the widest coal without them being about a foot. Total width of coal including partings of clay and shale is about five feet. All walls are very fine-grained bluish sandstone.

Mount Shasta Coal Company did considerable development on the coal near Oak Run, in the years from 1926 to 1929, under the supervision of Charles Magill of Redding. A large acreage was controlled at that time but it has been allowed to revert to the owners, Southern Pacific Pacific Land Company and others. The principal underground work was done on land assessed to Oscar R. Barnes of Ingot, in SW¼ of NW¼ of NE¼ of Sec. 4, T. 33 N., R. 1 W. The location of the main adit is shown on the accompanying map; also the locations of

several drill-holes put down to the coal. From the adit an incline was put down to the coal and beyond it through 40 ft. of sandstone to the Cretaceous conglomerate. A drift was then driven on the coal to make a total of about 650 ft. of work at this point. A section of the coal

No.	SURFACE ELEVATION	DEPTH TO COAL	DEPTH OF COAL
5	2011.0'	233.0'	6.0'
"			
8	2044.0'	441.0'	3.0'
"	"	592.0'	3.0'
9	2076.0'	272.5'	2.33'
"	"	281.5'	6.50'
10	2075.6'		
"			

FIG. 1.

appeared as follows: roof, gray sandy shale; bone-coal, 6 inches; shale, 4 inches; coal, 8 inches; shale, 2 inches; coal, 1 inch; shale, 3 inches; coal, 1 ft.; bone, 6 inches; coal, 1 ft., 6 inches; gray shale, 1 ft., 2

inches; coal, 4 inches; gray shale, 4 inches; coal, 8 inches; brown shale, 2 inches; coal, 1 ft., 8 inches. Some bone-coal was found below this, but no more good coal. From the work done in the drift, 110 tons of coal was hand-sorted and shipped for tests, and there was an additional 160 tons of fines, run of mine, and bone. Rejects left on the dump took fire at several points spontaneously, and have been entirely burned. The dip of this coal is a few degrees below horizontal in a northwesterly direction.

The following notes on the correlation of the coal beds at the main properties in the vicinity of Oak Run are abstracted from a report by George Watkin Evans, Consulting Engineer, Seattle, for Mount Shasta Coal Company. "Comparison of stratigraphic sections above and below the coal beds in the Barnes, Dakin and Luce slopes indicates that these probably all expose the same bed. Each of them has sandstone overlying the coal-bed, and in each case bluish-gray shales underlie the coal; also the cross-sections of the beds are rather similar. The Dakin slope exposes a considerable thickness of the overlying sandstone, and the Barnes slope was driven a great distance in the underlying material. The bottom is in a bed of hard conglomerate, and no coal of commercial value has been found below the Barnes bed. The bed in the Dakin drift dips toward the Dakin slope at an angle of 5° or 6°. This would account for the position of the bed so far down in the Dakin slope. The dip of the Barnes bed is such that it could easily be the bed outcropping on the Eldridge property." Additional information on work done at the Dakin and Luce properties is contained in State Mineralogist's Report XXII.

The following is abstracted from a report by James A. Kelly, Mining Engineer, Seattle, Washington. Based on actual tests, the following recoveries can be made by washing:

72%	18% to 20% ash
68%	15% to 17% ash
64%	12% to 14% ash

Taking a recovery of 65%, it would be divided as follows:

Buckwheat and finer	20% at 10% to 12% ash
Pea and finer	40% at 14% to 15% ash
1st grade nut and coarser	20% at 14% to 15% ash
2d grade nut and coarser	20% at 18% to 20% ash

Based on a 500-ton daily output, this would be:

100 tons high grade briquetting coal
100 tons 1st grade nut and coarser
100 tons 2d grade nut and coarser
200 tons of industrial coal suitable for stokers, powdered fuel, hand-fired steam plants. The coarser part of this could be used for producer gas, for domestic gas, or for small helical stokers.

Kelly suggested that the mine should be opened by a tunnel entirely through the ridge from a point in the NW¼ of the NW¼ Sec. 3 to a point in the SW¼ of the NE¼ Sec. 33. See accompanying map. He

made a preliminary estimate of the cost of equipping the mine to produce 750 tons per day, tipple and washery to produce 500 tons of merchantable coal per day from the 750 tons mine-run, mine yards, briquetting plant of 100 tons daily capacity, and a camp of 16 houses and a hotel, total: $292,997. He reports the following tests:

	Moisture %	*Volatile* %	*Fixed Carbon* %	*Ash* %	*B.T.U.*
Pacific Gas & Electric Co. (gas test)	10.46	34.08	34.39	21.07	8,230
Smith, Emery & Co. (gas test)	12.1	32.9	33.5	22.6	8,055
Smith, Emery & Co., Dec. 7, 1928	12.55	36.20	34.31	16.94	8,462
Smith, Emery & Co., Jan. 7, 1929				13.64	9,592
Smith, Emery & Co., Jan. 7, 1929				12.18	
Abbot A. Hanks, Inc.				12.80	
Abbot A. Hanks, Inc.				13.26	

Of six float and sink tests made by Kelly, the following single one is quoted as being near the average:

No. 3—Specific gravity of bath	1.44
Float	64%
Sink	36%
Ash analysis by Abbot A. Hanks, Inc., Jan. 28, 1929, Laboratory No. 58,358, Mark No. 3 float, dried sample, ash	15.06%

COPPER.

The important part of the Shasta County copper district lies a few miles west of the Sacramento River, at distances of 5 to 15 miles north of Redding. The main north-south line of the Southern Pacific Railroad follows the Sacramento River Canyon above Redding, and several stations and small towns such as Kennett, Keswick and Coram formerly served the copper mines. The population of these towns had greatly declined, but it is now rising again on account of the construction of the Shasta dam between Kennett and Coram. The reservoir will flood 36 miles of the present railroad, which must be moved. The topography is very rugged, with steep slopes rising from the river at an altitude of 500 feet to peaks at 4500 feet. Some production of copper has been made from the Bully Hill and Ingot districts, 25 miles northeast of Redding.

The deposits have produced 686,000,000 pounds of copper, which was sold for $110,000,000. Considerable gold and silver produced from the same ores added to their value. The copper production of the district was at its height from 1898 to 1919. Except for a spurt in 1924, it then gradually declined to practically nothing at present (1939). The smelters of Shasta County have all been dismantled, and ore must now be shipped either as raw ore or as flotation concentrate, requiring a minimum price of 12 cents a pound for copper to cover costs. Metal production of the district is now confined largely to gold and a little silver, which are extracted from the gossan[1] above the flat-lying bodies of sulphide. One mine is equipped to produce several hundred tons per day of pyrite for the manufacture of sulphuric acid, and a little copper is derived from residues, also a little from mine water.

[1] Averill, C. V., The Mountain Copper Co., Ltd., cyanide treatment of gossan: California State Mineralogist's Report XXVII, pp. 129-139, 1931. Later article of same title: California State Mineralogist's Report XXXIV, pp. 312-330, 1938.

The formation of outstanding interest in the copper belt is the alaskite porphyry, which has also been called Balaklala rhyolite[1] and granite porphyry[2]—a silica-rich albite granite porphyry. The most common variety is a greenish-gray rock of very fine grain. The groundmass is a microgranular mixture of quartz and feldspar, and the phenocrysts are usually minute also. The phenocrysts consist of quartz and albite, rarely oligoclase-albite; and there are small grains of magnetite, chlorite, and epidote, possibly derived from original biotite; also accessory apatite, titanite, and zircon. Another variety contains quartz phenocrysts an eighth of an inch or more in diameter. Still another variety is brecciated. The alaskite porphyry is apparently a complicated igneous series intruding the pre-Devonian Copley meta-andesite, the shales of the Kennett formation (Devonian), the shales of the Bragdon formation (Carboniferous), and the shales and tuffs of the Pit formation (Triassic). The alaskite porphyry must be as young as late Triassic, and its intrusion was probably contemporaneous with the late Jurassic mountain-making in the Sierra-Nevada, 100 miles to the southeast.

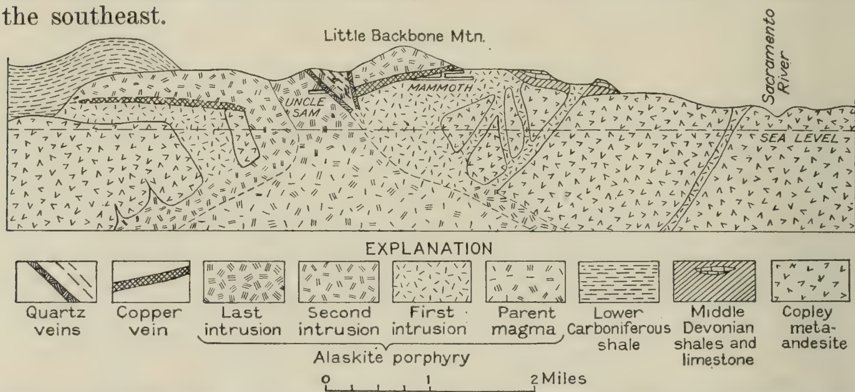

FIG. 2. Idealized vertical section of part of Shasta County copper belt, looking north. Contacts between various intrusions of alaskite porphyry are generalized, and are intended to show the complexity of the intrusion.

With the exception of Hershey,[3] who mapped an area at Iron Mountain, all geologists who have mapped the general geology of the region have mapped the alaskite porphyry as a single formation. This statement does not include mining-geologists who have confined their work to single mines. At one mine, the geologists believe that the variety of alaskite porphyry carrying large quartz phenocrysts was intruded as a sill into the other varieties. To better distinguish it, they now call the coarser variety quartz porphyry. The zone of shearing or faulting which was later mineralized to form some of the largest ore-bodies is believed to have followed in a general way the lower contact of this sill of quartz porphyry. Hence the hanging wall of the ore is usually quartz porphyry (alaskite porphyry with quartz phenocrysts) and the footwall is brecciated alaskite porphyry. Thus, in working out the structure in a search for new bodies of ore, it is

[1] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Redding folio (no. 138), 1906.

[2] Hinds, N. E. A., Geologic formations of the Redding-Weaverville districts, northern California: California State Mineralogist's Report XXIX, pp. 76-122, 1933.

[3] Hershey, O. H., The geology of Iron Mountain (with map): Min. and Sci. Press, vol. 111, pp. 633-638, 1915. The map is reproduced in California State Mineralogist's Report XXIX, 1933.

very important to map these varieties of alaskite porphyry separately. This is not as easy as it may appear because the intense alteration near the ore-bodies tends to make all of the rocks look alike.

At another mine no great effort is made to map the intrusions of alaskite porphyry separately. Effort is directed toward locating shear-zones which control the mineralization.

At one property post-mineral faulting is believed to account for segments of the flat-lying ore-bodies having a difference in elevation of 400 feet. At another property post-mineral faults are believed to be of minor importance with displacements of less than 30 feet, and the ore-bodies are thought to have originally formed on shear zones at several different elevations.

Hence there are numerous problems connected with the structure and mineralization of this region which have not yet been solved. A geologist who can solve them may succeed also in discovering additional large bodies of ore. Perhaps a geophysical method will be improved to a degree that it will locate additional ore.

The copper deposits form large flat-lying masses of pyritic ore, with maximum dimensions of 1200 ft. in length, 300 ft. in width, and 300 ft. in thickness. The Iron Mountain ore body, before a great part of it was converted into gossan, is thought to have contained 20,000,000 tons.[1] These deposits are replacement deposits in the alaskite porphyry, probably following zones of shattering. The ore minerals are pyrite, chalcopyrite, sphalerite, and small amounts of galena, bornite, and chalcocite. The grade of these heavy sulphide ores was roughly 3% or 3½% of copper, and $1.50 to $2 per ton in gold and silver. Ore showing sulphide enrichment has been found in some of the mines, but it is not important. Some copper production has come from small quartz veins carrying chalcopyrite, which dip at steep angles beneath the tabular masses of pyritic ore. This ore is amenable to concentration by flotation. Mines on which recent development work has been done are mentioned below. Further details on the older mines are contained in a report by Tucker,[2] which was brought up to date in 1926 by Logan[3] in State Mineralogist's Report XXII. Locations are given in the accompanying table of mines.

Afterthought Mine is assessed to *Afterthought Zinc Mining Co.*, Ingot. It is located in Sec. 10, 11, T. 33 N., R. 2 W., at Ingot. E. L. Ralston, Box 538, Redding, is in charge. Bodies of heavy sulphide ore containing pyrite, sphalerite, chalcopyrite, and traces of bornite, and assaying 15% zinc, 2% copper, 5 ounces silver to the ton, and a little gold, have been developed here. A smelter and a 300-ton flotation plant were operated for short periods, and later ore was sent to Bully Hill over an aerial cable-tram, 8½ miles long. The difficulty with this ore seems to be that the zinc and copper sulphides are so intimately associated that grinding up to the economic limit (say 300-mesh) is not sufficient to separate them. The property has not been operated during recent years, and practically all machinery has been junked.

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[1] Graton, L. C., The occurrence of copper in Shasta County, California: U. S. Geol. Survey Bull. 430, pp. 71-111, 1910.

[2] Tucker, W. B., Copper resources of Shasta County: California State Mineralogist's Report XX, pp. 419-447, 1924.

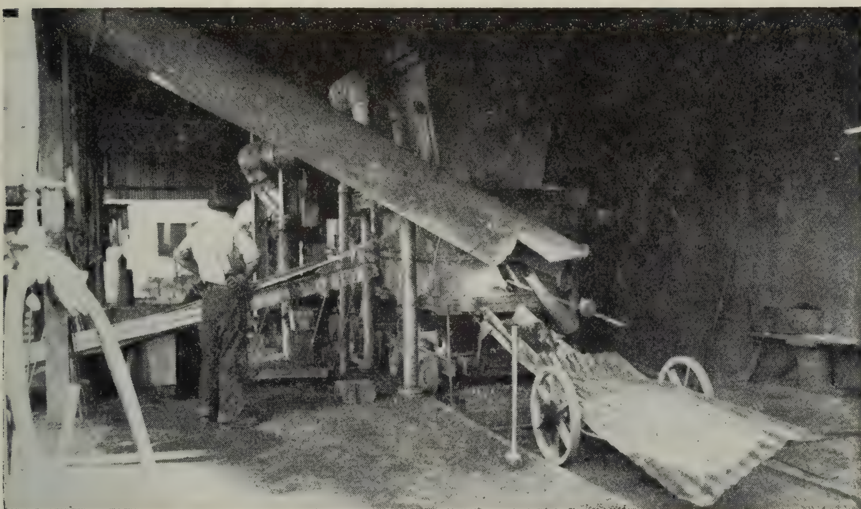
[3] Logan, C. A., Shasta County, copper: State Mineralogist's Report XXII, pp. 138-162, 1926.

Backbone Gold Mining Co. operated the *Golinsky* mine under a lease and option in 1937, and owns adjoining land, on which a small smelter was built. The location is Sec. 28, 33, T. 34 N., R. 5 W., four miles above Kennett by a dirt road built on a grade of about 10%. Moe Platt, 30 Broad Street, New York City, was president, and O. C. Wright, now of Igo, California, was secretary. J. McAuliffe was general manager at Kennett.

Smelter of Backbone Gold Mining Co.

Mace smelter, charging floor.

The company controlled 320 acres of land, the eight patented mining claims of the Golinsky, and the NW¼ Sec. 33. The Golinsky ore comprises flat-lying lenses of pyritic ore and gossan formed from the pyritic ore by oxidation near the surface. The irregular, flat-lying nature of the ore makes strike and dip uncertain. It probably strikes a little north of east and dips to the south at a small angle. Principal development is from two adit levels, 100 ft. apart vertically. The lower adit (no. 2) is entirely beneath the ore body, so far as is known at the present time. Considerable stoping has been done from the upper adit (no. 1) in former operations. Present workings are largely on what was formerly an intermediate, 65 ft. above the lowest adit. The intermediate has been continued to the surface to make a new adit and has been retimbered. In July, 1937, it was being driven ahead in sulphide ore. The adits are roughly 300 ft. in length.



Mace smelter, lower floor.

The company installed a no. 4 Mace furnace rated at 50 tons per 24 hours, and a no. 5 Mace furnace rated at 100 tons per 24 hours. They are small blast furnaces with vertical shaft, and the lower part is water-jacketed. The 50-ton furnace was operated for a short time, but the 100-ton furnace was not operated. Fines were sintered before smelting on a sintering machine equipped with an oil burner. A typical charge was as follows: 300 lb. massive iron sulphides (25% iron), 340 lb. sinter, 160 lb. limestone, 75 lb. coke. The limestone was obtained from the old Holt and Gregg quarry, which is on the road to Kennett, about a mile and a half from the smelter. The first 2058 tons of ore smelted yielded 240.6 tons of matte, which was shipped to the smelter of the American Smelting and Refining Co. at Tacoma, Washington, for further treatment. According to the operators of the Backbone smelter, this matte contained 13% copper, 2 ounces gold and 30 ounces silver per ton of matte. The outfit has been idle during 1938.

Balaklala Mine in Sec. 10, 11, 12, 13, 14, 17, 20, 21, T. 33 N., R. 6 W., near Kennett, is assessed to *First National Copper Co.,* 830 Mandana Boulevard, Oakland. It has produced very little copper since Logan's report of 1926, at which time it was leased by Mason Valley Mines Co. The gossan has been given some consideration as a possible producer of gold, and the mine is mentioned again on a later page under that heading.

Bully Hill Mines have produced considerable copper, but not during recent years. The last production there was zinc oxide, and the mines are mentioned on a later page, under the heading, zinc.

Canyon Creek Claims (Consolidated Copper Co.) are mentioned here because they apparently have not been visited before by a representative of this division. E. Baker, 239 Edelen Ave., Los Gatos, held 1000 acres of unpatented mining claims in Sec. 4 and adjoining sections, T. 36 N., R. 1 W., eight miles by river-trail down the Pit River from Big Bend. Reports on the property by Guy M. Vail and John A. Rice of San Francisco are on file in the Redding office of this division.

The country rock appears to be an andesitic or basaltic lava with considerable variation in grain, varying in color from dark brown to black. Some of it contains short, stout feldspar crystals, three-eighths of an inch in length. The black variety is of very fine grain. Some vesicular lava was noted also. Fractures in the rock show green copper minerals, apparently introduced by surface waters from above. In one of the few fractures containing these green minerals still in place, a cross-fracture cuts off the mineralization only a few feet below the surface. The width of mineralization is only a few inches. Most of the mineralized material has been gouged out by the workings, and is seen largely on the dumps. The solid rock beneath the few feet of fractured rock nearest the surface was not observed to contain any copper. Only one small piece of primary ore was seen. This was a piece of white quartz containing possibly a little sulphide in addition to the green malachite. It was found on the floor of one of the adits. One 130-ft. adit was examined, one of 30 ft., and several open cuts. These are scattered for nearly a mile on the west side of the steep ridge between Canyon Cr. and Pit River. The top of the ridge was examined for about half a mile also. A little trenching had been done here in the lava.

Golinsky—see Backbone Gold Mining Co.

Greenhorn Mine is assessed to *Greenhorn Mining Co.,* 2135 Sacramento St., San Francisco. The location is in Sec. 6, T. 32 N., R. 7 W., 23 miles northwest of Redding near the Weaverville highway. The mine is developed by six adit levels ranging in elevation from 1860 ft. to 2207 ft., which expose one of the flat-lying lenses of pyritic ore such as have been so extensively mined in the Keswick and Kennett areas to the east. The lens dips into the mountain in a northwesterly direction at an angle of 17° below horizontal. According to Albert Hanford, who was in charge of the last work done on the copper ore, the upper part of this lens contains 80,000 tons of pyritic ore running

4.3% copper. Below this is a larger body of pyritic ore running 1% to 2% copper and $1.50 per ton in gold and silver.

In 1929, when the price of copper was high, a number of carloads of ore were mined by hand from an enriched zone just above the pyritic ore, and were shipped to the Tacoma smelter of the American Smelting and Refining Co. This ore was largely chalcocite and cuprite with some malachite and native copper, and contained roughly 30% copper as shipped.

The upper part of this body of sulphides has been converted to gossan, and the possibility of treating this for its gold and silver content is being considered. This is mentioned again under the heading, gold. There is no equipment on the property at the present time (1938).

United States Smelting, Refining and Mining Co., c/o E. A. Hamilton, 921 Newhouse Building, Salt Lake City, Utah, formerly operated a smelter at Kennett with a capacity of 2200 tons per day of pyritic ore, but this has been junked. The *Mammoth* mine was reopened in 1937 for a development campaign. As ore recently discovered is zinc rather than copper, it is mentioned again under the heading, zinc. Gossan is mentioned under the heading of gold.

DIATOMITE.

Large deposits of diatomite (diatomaceous earth) are located along Pit River from the region a few miles east of the mouth of Hat Creek on both streams, downstream to Pit 3 powerhouse. Data given here are largely abstracted from Logan's[1] report of 1926. The material varies in quality as regards compactness and tint, in different localities, but an immense tonnage of a good grade is in sight. The region mentioned, in which mining claims have been located and are being held for this material, stretches for over 12 miles east and west, and four miles north and south. Not all of the land within this area is being held for mining, as parts of it had previously been appropriated for farms, timber and power; although some of this land is underlain at very shallow depth by the mineral deposits. The full extent of diatomite deposits in Shasta County has not yet been definitely determined, and probably a great deal more of it exists than has been realized, in the eastern and northeastern sections where volcanic activity was prevalent. Deposits were formed where the relatively recent volcanic rocks dammed rivers and creeks, forming lakes where the type of life flourished that leaves behind these microscopic siliceous skeletons. Later volcanic flows then covered and preserved the deposits. Present streams have cut through the lava in places, and have exposed the diatomite. Conditions will preclude the probability of development of some such areas, such as distance from railroads, amount of overburden, and location below ground water level, which would mean a saturated deposit and expensive operation. Goose Valley, the region of Fall River Mills, and some of the more remote lakes that were formed by lava dams contain such deposits. The size of the individual diatoms in these fresh-water deposits is much smaller than in salt-water deposits,

[1] Logan, C. A., Shasta County: State Mineralogist's Report XXII, pp. 163-166 (with map), 1926.

and this gives the diatomite somewhat different properties for such uses as filtration. In addition to these Pit River deposits, one is known 29 miles east of Anderson, in the southeastern part of the county.

Mount Shasta Silica Co., J. M. White, president, M. H. Neimeier, secretary, Weed, transferred 56 claims of the Insulator group and 9 claims of the Shasta Diatomite group, total 10,400 acres, to William C. Crittenden in December, 1930, and Crittenden then transferred them to *General Kieselguhr Corporation,* the last known address of which was 519 California St., San Francisco. Claims are all unpatented, and lie along the Pit River principally on the north side of the canyon from Sec. 33, T. 37 N., R. 2 E., to Sec. 10, T. 36 N., R. 4 E. Burney, the nearest town, is 13½ to 20 miles by good roads from the various claims. The claims are on or near the line of Pacific Gas & Electric Company's broad-gage railroad from Bartle to their power houses on Pit River.

Insulator group lies north of Pit River and is a solid block of locations, 3½ miles long in an east and west direction, and from 1½ to 3 miles wide. The railroad runs along the north bank of the river, 25 feet or less above the water level, along the entire frontage of this group. The deposits extend from river level, 2752-ft. elevation, to within a short distance of the top of the ridge, where the diatomite is covered by lava. According to aneroid reading it is 340 ft. vertically from the railroad track to the contact of overlying lava. Diatomite outcrops for this entire vertical range, and for about one-half mile north of the river, practically without overburden, the shallow soil cover not being enough to hide the white color.

Several of the railroad cuts have been made through the deposit, and show its character. It is partly pure white, and partly flecked by faint lines and splotches of yellowish iron oxide, but this stain is so faint that the amount of impurity is manifestly very small. The banks exposed show a material of uniform and homogeneous character. Taken as a whole, the various openings show a remarkably small amount of visible impurities. Some narrow sand seams occur; also infrequent narrow seams called 'flint', which is perhaps partly opalized material. The deposits on this group show various degrees of density or consolidation, although as a whole they are probably a little denser than those on other groups. East of the former camp, one detached deposit shows a bed sufficiently compact for sawing into blocks and bricks.

Since the deposition of the lava cap, erosion by the river and its small tributaries has dissected the deposit, leaving several detached bodies along the different ridges, so that a tremendous available tonnage, above water level, has been exposed by nature.

The Shasta Diatomite Group of claims covers all of two unsurveyed sections, which would be Sec. 2, 3, T. 36 N., R. 2 E., if surveyed. They are on the north side of the river, east of Pit 3 powerhouse, and reach an elevation of 2000 ft. above the river. Two short adits have been run here showing a very high quality of material, pure white, light, and fine-grained. These claims are well timbered and the outcrop is not conspicuous, differing in this respect from the claims of the Insulator Group, most of which have a sparse growth of scrub oak.

Some years ago considerable work was done on the deposits, including the installation of a large plant for grinding and sizing the diato-

mite. So far as is known, this was not operated, and most of the production has been confined to small lots for local use in insulating refrigerators in meat-markets and creameries.

The following analyses were made by Smith, Emery and Co. for Mount Shasta Silica Company:

Analyses of samples of diatomaceous earth from various claims of Mt. Shasta Silica Company.

Location	SiO_2	Fe_2O_3	Al_2O_3	CaO
Grade near Warners Bridge	81.39	2.18	8.32	2.27
R. R. cut near camp	82.09	1.65	8.09	1.15
Sec. 25, T. 2 N., R. 37 E. (Forestry Sta.)	91.33	0.92	2.59	0.66
Sec. 26, T. 2 N., R. 37 E.	90.58	0.65	1.43	0.27
Soldier Creek	90.28	1.26	2.52	0.15
No. 12, extreme west end	97.16	nil	trace	trace
Sheep Spring	96.02	0.62	1.03	0.12
No. A 107	88.05	1.08	6.25	1.00
No. A 52 R. R. cut next camp	90.25	0.65	1.55	0.25

GOLD.

Geology.

The geology of the Weaverville quadrangle, which includes the French Gulch gold-quartz district, has been described by Ferguson[1] and by Hinds.[2]

The oldest formation in the immediate vicinity of the French Gulch mines is a pre-middle-Devonian series of vesicular lava flows, with minor amounts of tuff and breccia, called the Copley-meta-andesite. The rock was apparently a pyroxene andesite but it has been greatly altered by regional metamorphism. Overlying this is the Bragdon formation (Carboniferous) consisting of conglomerates, sandstones and carbonaceous slates, the slates greatly predominating.

A great variety of intrusive rocks is found in the Weaverville quadrangle, including serpentinized peridotite and saxonite, quartz diorite, granodiorite, and several types of porphyries and lamprophyres. Alaskite porphyry (called Balaklala rhyolite by Diller[3]), which is the most prominent formation of the copper mines, and a soda granite porphyry are closely allied formations. Probably the most prominent feature at French Gulch is the intrusion of dikes of diorite porphyry, locally called 'bird's eye porphyry', into the Copley meta-andesite and the Bragdon formation. The quartz veins are often found on the contacts of these intrusive dikes. A section of the Brown Bear mine, which is just to the west across the county-line, was published in State Mineralogist's Report XXIX.[4] A feature that has received no attention until recently is the presence of intrusive dikes of andesite similar in appearance to the Copley meta-andesite. Further study of these may help in the discovery of additional bodies of ore. They are mentioned on a later page under the heading of Washington mine. The veins are of white quartz with small amounts of pyrite, galena, sphalerite, arsenopyrite, and free gold.

Somewhat similar veins are found in the Old Diggings district but they are likely to be larger and lower in grade. They are associated with a rhyolitic dike which has been intruded into Copley meta-andesite.

[1] Ferguson, H. G., Gold lodes of the Weaverville quadrangle, California: U. S. Geol. Survey Bull. 540-A, pp. 16-73, 1913. (Out of print.)

[2] Hinds, N. E. A., Geologic formations of the Redding-Weaverville districts, northern California, Calif. State Mineralogist's Report XXIX, pp. 77-122, 1933.

[3] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Redding folio (No. 138), 1906.

[4] Averill, C. V., Gold deposits of the Redding and Weaverville quadrangles: Calif. State Mineralogist's Report XXIX, pp. 3-73, 1933.

It may or may not be related to the alaskite porphyry. It has received very little attention. A study of it might lead to a better understanding of the mineralization, and the discovery of additional ore.

Very few of the gold mines of Shasta County have had the geology mapped on the large scale now used by most successful mining companies, that is on a scale of 40 ft. or 50 ft. to one inch. Such work would lead to a better understanding of the structure, faulting, and mineralization, and would almost certainly bring about the discovery of additional ore.

With regard to placer gold, the greatest known reserve is south of Igo on what is apparently an old terrace of Clear Creek. The gravels of this terrace have been reworked by Dry Creek, and dragline dredging is being done there. This dredging and that on Roaring River to the southwest have been described in a recent publication[1] of this division; hence only dredging that has been started more recently is described here.

Mines.

American Mine comprises six unpatented mining claims in Sec. 12, 13, T. 33 N., R. 7 W., four miles from French Gulch. The lowest adit (no. 5) is some 700 feet higher in elevation than Cline Gulch, on which the new mill mentioned below was built. A 2-ft. quartz vein cuts through the Bragdon formation, cherty conglomerate and black slate. The strike is east and west and the dip is nearly vertical. Ore is white quartz containing free gold and a small percentage of auriferous pyrite and galena. On the upper levels, it is stained brown by the oxidation of the iron. Old workings are seen at various elevations from the lower (no. 5 adit) clear to the outcrop, some 800 ft. or 900 ft. higher in elevation. No. 5 adit level runs northerly for 1150 ft. to tap the vein, on which are old drifts 150 ft. to the east and 270 ft. to the west. At a point 60 ft. west of the adit, a winze had been sunk a distance of 110 ft. on the vein.

In 1934, the mine was taken on lease and option by *Abacada Mining Corporation,* of which the chairman of the board of directors was George H. Proctor, and the treasurer was Clifton E. Turner, 50 Church Street, New York City. N. D. Bertram was general superintendent at French Gulch. These operators unwatered the 110-ft. winze, and sank it an additional 100 ft. Drifts were run out on both the 100-ft. level and the 200-ft. level. On the 100-ft. level, at a point 110 ft. east of the winze, the face showed black slate with numerous bands of white quartz, an inch to several inches wide. Some good ore is said to have been opened up in the east drift on the 200-ft. level, but these workings are now all full of water. Additional adit levels could be run to this vein from points lower on the mountain, but they would be rather long.

Abacada Mining Corporation built a mill containing all new machinery, a 9-inch by 21-inch Telsmith jaw crusher and bucket elevator driven by a 20 hp. electric motor, and two high-speed Marcy ball mills with Cark-Todd amalgamator and Dorr classifier driven by

[1] Averill, C. V., Gold dredging in Shasta, Siskiyou and Trinity counties: Calif. State Mineralogist's Report XXXIV, pp. 96-126, 1938.

a 60-hp. motor. Six Fahrenwald flotation cells followed, four roughers and two cleaners, driven by a 20-hp. motor; also two no. 6 Wilfley tables and a Wilfley sand pump. The rated capacity was 60 tons per day, grinding to 100-mesh. The mill was operated for only a few months, and was later purchased by E. E. Erich, and moved to the Brown Bear mine at the other end of the district in Trinity County. The American mine has been idle during 1938.

Backbone Gold Mining Co. is described under the heading of copper.

Balaklala Mine in Sec. 10, 11, 12, 13, 14, 17, 20, 21, T. 33 N., R 6 W. is assessed to First National Copper Co., 830 Mandana Boulevard, Oakland. It is one of the old copper producers of the Kennett area, and has received some recent consideration as a gold producer from gossan. Deposits of gossan in three different locations are mentioned in State Mineralogist's Report XXIX.

In 1934, the gossan, particularly that at the 'Angle Station,' was extensively sampled by M. C. Dann, H. R. Van Wagenen, and associates of Los Angeles. The old road from Coram to the angle-station had been entirely washed out, and this was rebuilt with a power shovel. Plans called for the construction of a cyanide plant to extract gold from the gossan, but this has not been built.

Ballou Mine (Manzanita or Falls) in Sec. 7, 18, T. 31 N., R. 6 W., six miles northwest of Igo, is assessed to May V. Ballou, Anderson. R. S. Ballou of Igo is leasing the five patented claims and has located two additional claims adjoining. Quartz veins occur here in the quartz diorite, into which a few dark-colored, fine-grained dikes have been intruded. Following is a description of development work on the various claims.

Hope claim. A quartz vein, 2 ft. to 3 ft. in width, carrying fine-grained pyrite, is seen in an open cut. It strikes north and south and has a nearly vertical dip. Old workings, now caved, are described by R. S. Ballou as follows: 525-ft. adit, of which 60 ft. is crosscut, balance drifting on the vein. At the 400-ft. point is a stope, 100 ft. long, 50 ft. to 60 ft. high, and 2½ ft. to 3 ft. wide. Part of the vein is quite low in grade, but high-grade streaks raise the average to make a milling grade of ore. A raise from the stope, 115 ft. long, reaches the surface. Below the stope is a 25-ft. winze, in the bottom of which a 2-ft. width of good ore is stated to have been exposed.

Manzanita claim. An open crosscut adit, 100 ft. long, must be driven 30 ft. farther to reach the main Manzanita vein, 3 ft. wide, at the bottom of an old 50-ft. shaft, now caved. Small production has recently been made from a 1-ft. vein cut by this adit, on which 60 ft. of drifting has been done. On the claim is a parallel vein, 100 ft. away, from which some production of oxidized ore was made years ago.

Sulphide claim is developed by a 300-ft. adit, 75 ft. of which is crosscut, the balance drifting on a 4 ft. to 5 ft. vein. The ore is white quartz containing roughly 10% pyrite. The adit is partly open, but is in poor repair.

Falls claim is developed by a drift-adit on the east vein, 140 ft long, showing about 1 ft. of quartz to a point near the face, where it intersects a second vein. Ballou estimates by panning that the interesction forms a body of mill-ore with a width of 3 ft. The strike is N. 20° E., and the vein dips steeply to the east. At a point 40 ft. lower in elevation is a crosscut adit, 105 ft. long, running N. 51° W., which cuts the same vein at the 50-ft. point. It shows about 12 ft. of silicified material, possibly dike-rock, with some mixed vein-quartz, especially on the hanging wall side. It is disturbed and broken by a flat fault and is low in grade here. Ballou estimates that if this adit is driven ahead to a total length of 900 ft. to 1000 ft., four additional veins will be cut, Zinc vein, West Falls vein, Sulphide vein, and Hope vein. Drifts to the north and northeast would give maximum backs of 400 ft. to 600 ft. on these veins.

Ballou is mining oxidized ore on a small scale, and hauling it to a Straub stamp mill on the property, below which treatment is by amalgamation. Power is furnished by a Pelton wheel supplied with water through a 10-inch pipe under a head of 65 ft. When the water supply gets low, boosting is done with a small gasoline engine.

Bjork Group comprises five unpatented claims in Sec. 6, T. 33 N., R. 6 W., held by J. W. Thews of Redding, and James Conners of French Gulch. The claims are reached by seven miles of road north of French Gulch, then half a mile of steep mountain trail. An 80-ft. shaft exposes a 3-ft. quartz vein with an east and west strike and a dip of 45° south, which contains some gold. The shaft was partly filled with water when visited. At a point 400 ft. lower in elevation is an adit with a total length including branches of 200 ft. Recent work is in a 50-ft. drift from this adit, and a vein with a maximum width of 18 inches is exposed. Parts of it are only a few inches wide. The strike is N. 30° E., and the dip is 45° west. It has recently produced gold ore of very good grade.

In these workings, country rock is Copley meta-andesite, into which may be intruded dikes of andesite with a similar appearance. The Bragdon slates are seen at the west end of the property, and a large dike of diorite porphyry, typical of the French Gulch District, is seen to the northwest.

Black Diamond is a group of 10 unpatented claims in Sec. 5, T. 31 N., R. 5 W., four miles west of Redding, held by T. S. Callender of Redding, Wells Towers, and Mabel Zimmerman of Westwood. Callendar has recently produced small quantities of gold ore of very high grade from a vertical seam in the Copley meta-andesite. It is opened by a 15-ft. shaft, on which an air-compressor is now being installed. Several quartz veins on this property are mentioned in State Mineralogist's Report XVIII, p. 296. The Grand View group of three claims nearby is held also.

Blue Bird Gold Mine is in Sec. 31, T. 33 N., R. 5 W., half a mile north of the Menzel mine. It is held by R. M. Rutter, William Owens, and Richard Woehr of Redding. The latter states that a 30-ft. shaft develops a vein of milling ore 5 ft. to 6 ft. wide. The property has not been visited.

Blue Gravel Mine.

Blue Gravel Mine is on the Redding Grant, two miles southwest of Redding on what would be Sec. 2, T. 31 N., R. 5 W., if the survey were carried into the grant. The land is owned by the City of Redding and is leased to Larsen Bros., 5220 21st Avenue, Sacramento. Placer gold has been mined from the gravel on this property on and off for many years, and the present operators started work on the gravel. Later a zone of quartz stringers was found in the Copley meta-andesite beneath the gravel, and a vertical shaft was sunk to develop it. The shaft passed through the gravel at the 25-ft. point and was continued to a depth of 100 ft. and lateral work was done at the 60-ft. and the 100-ft. levels. A shoot of good gold ore, 100 ft. long and 18 inches wide, has been mined out to the 100-ft. level. It strikes northeast and southwest and dips 40° southeast. Oxidized ore was found above the 60-ft. level and sulphides below with free gold in both kinds of ore. Ore was milled at the rate of about 20 tons per day during six months of 1938, in a new mill containing a jaw-crusher, Straub ball mill, and plates for amalgamation. Two Wilfley tables were being added late in 1938.

Boswell Group is in Sec. 7, T. 31 N., R. 5 W., seven miles west of Redding. It contains several large quartz veins associated with andesitic dikes in the quartz diorite as described in State Mineralogist's Report XXIX, pp. 11-12.

In 1933, a mill of very unusual design was built on this property. It was expected to pulverize the ore by means of impact resulting from dropping the ore from a height of 40 ft. To raise the ore to this height a device similar to a bucket elevator was used, but it was made of linkage similar to that used on the tracks of a caterpillar tractor. Treatment was to be by amalgamation and gravity concentration. After a short trial run, the mill was dismantled.

A part of the property is now held by Richstrike Gold Mines, Ltd., which see.

Brunswick—see Miners' Group of Mines.

Buena Vista Mine is a property of three unpatented claims in Sec. 5, T. 31 N., R. 5 W., five miles by road west of Redding. It is owned by H. G. Graves of Redding. Country rock is Copley meta-andesite intruded by dikes. Just to the west of the main workings, an andesitic dike containing phenocrysts of plagioclase feldspar $\frac{1}{8}$-inch long, and smaller phenocrysts of altered biotite in a fine-grained groundmass, is seen. To the east of the workings is the outcrop of a rhyolitic dike.

The property was described in State Mineralogist's Report XXIX for 1933, p. 15. At that time, an incline shaft had been driven on the vein, the upper 50 ft. at an angle of 30° from horizontal, and the lower 60 ft. at an angle of 45°. Some faulting was evident at the 50-ft. level. The vein averaged about 5 ft. in width above the fault. It contains quartz and sulphides, partly oxidized, including a little chalcopyrite. Oxidation of this has produced some green staining. About 100 ft. of drifting had been done.

Since that time the incline has been continued to the 187-ft. point, and 100 ft. of drifting was done at the bottom. This work did not develop any ore. A branch was then driven in a southerly direction at the 30-ft. point in the incline for a distance of 70 ft. at angles from 26° to 8° below horizontal. Workings at the bottom total 136 ft. at an elevation of 36 ft. below the collar of the shaft. This includes a 116-ft. crosscut in a southeasterly direction that passes through the rhyolitic dike. A second branch incline is 83 ft. long. These workings expose segments of a quartz vein 4 ft. to 12 ft. wide, apparently disturbed by step faulting. It is said to carry high assays in gold.

Equipment includes an 8 by 8-inch compressor belted to a gasoline engine, and a 15-hp. gasoline hoist. Graves is planning to install a 10-ton Straub ball mill and a flotation plant immediately.

Cates Group comprises seven unpatented claims in Sec. 4, T. 35 N., R. 6 W., 15 miles west of Delta, held by J. M. Cates, Bayles, Shasta County. Cates located the claims in 1930, cleaned out old adits, and did some new work. A crosscut-adit, 355 ft. long, cuts the first vein at the 181-ft. point, where it has a maximum width of 25 ft. Drifts have been driven 28 ft. to the south and 75 ft. to the north on this vein on the footwall side; also 32 ft. to the south and 8 ft. to the north on the hanging wall side. A raise on the footwall, 37 ft. high, is placed to hole to a shaft on the surface, which is 80 ft. higher in elevation than the floor of the adit. The shaft and an open cut expose the vein to a depth of 13 ft. The dip is 45° west. The vein narrows in both directions from the main crosscut, and to the north pinches to a gouge seam. Additional work is needed to actually block out ore; but Cates estimates a block partially developed of 50 ft. long by 24 ft. wide of milling ore from this level to the surface. In this main adit, 32 ft. beyond the main vein, a second vein with a width of 12 inches to 18 inches is cut, and drifts have been driven for short distances on it.

At a point 110 ft. lower in elevation is a 154-ft. crosscut adit, caved at the 50-ft. point. Cates estimates that it must be driven 450 ft. more to reach the vein. Country rock is black slate in the bottom of this lower adit; above is a green andesitic rock. An irregular andesitic

dike with large phenocrysts occurs on the footwall of the vein. Seven surface cuts expose quartz on other parts of the property.

Desmond Mine (Aurora) includes two claims, Aurora and Red Cross, in Sec. 4 (?), T. 32 N., R. 6 W., three miles up Whisky Creek from Schilling, held by Mrs. Charlotte J. Desmond of Redding. It is leased to E. H. Elliott, John M. Berry, and Thomas Berry of Redding. A vein consisting of 4ft. to 5 ft. of quartz and mineralized country rock strikes N. 50° E., and dips 50° southeast. It is developed by a 135-ft. shaft following the dip of the vein, and an adit connecting with the shaft. The adit continues beyond the shaft, and there is a winze 40 ft. deep from the adit-level with a drift at the bottom, making a total of roughly 200 ft. of development work in addition to the shaft. The shaft is equipped with a 12-hp. gasoline hoist, and a portable type Ingersoll compressor of 220 cfm. has recently been installed. When visited the mine was idle and workings below the adit-level (the 35-ft. level of the shaft) were full of water. According to Elliott, he and two different partners shipped 150 tons of $20-ore, two or three years ago. The value is in gold.

Eiller Mine (Gold Hill) in Sec. 11, T. 32 N., R. 6 W., 10 miles northwest of Redding, was operated by Ed. D. Westbrook of Redding, in 1935. Work was done in an adit, which ran southwest for 42 ft., then turned to the west to follow 6 inches to 8 inches of gouge with occasional bunches of quartz. At the 180-ft. point in the drift, a 4-ft. width of quartz was exposed, which was said to give good assays in gold.

A mill of 25 tons rated daily capacity was installed. It consisted of a crusher, 7 inches by 9 inches; home-made ball mill, 36 inches by 54 inches, mounted on a truck, and driven by the truck-engine; and four home-made flotation cells. The crusher was driven by a 6-hp. gasoline engine, and a compressor by a 10-hp. oil engine.

Gladstone Mine in Sec. 18, T. 33 N., R. 6 W., and adjoining sections, is assessed to *Hazel Gold Mining Co.*, c/o Dr. J. F. Peattie, 79 New Montgomery Street, San Francisco. This is the deepest mine of the region, and has made a production of gold variously estimated at between $3,000,000 and $5,000,000. The vein occurs in the slate, sandstone, and conglomerate of the Bragdon formation in a crushed zone 60 ft. wide. The upper part of the mine to a depth of 1000 ft. was worked through adits, from the lowest of which a shaft was sunk 1400 ft., with levels about 100 ft. apart.

R. L. Parker of French Gulch was planning to re-open the mine late in 1938. The vein which has been productive in the adjoining American mine is said to have been located at several levels by adits on the J.I.C. claim of the Gladstone. Parker plans to work this vein, and not to unwater the old shaft.

Gold Acres Dredging Co., controlled by P. G. Flummerfelt and Miss Helen Ardelle, 658 Haddon Road, Oakland, operated a dragline dredge in Sec. 2, T. 29 N., R. 6 W., 14 miles west of Cottonwood. Their first washing plant built on a wooden barge, with riffle-tables for recovering gold and platinum, was mentioned in State Mineral-

ogist's Report XXXIV, chapter for April, 1938.[1] A Bodinson all-steel plant with jigs instead of riffle-tables was installed later. It had a rated capacity of 150 bank yards per hour.

Gold Acres Dredge equipped with jigs.

The hull was 36 ft. wide by 44 ft. long by 4 ft. deep, made of six steel pontoons with seams electrically welded. Built into the hull was a suction well for the main pump with a water-supply pipe below water line running from the sump to a side inlet, which was protected by a large screen box covered with screen of ½-inch mesh. The feed hopper was 12 ft. wide and 10 ft. fore and aft, provided with a grizzley with 14-inch spaces, and with a spout 35 inches in diameter to discharge into the trommel. The trommel was 60 inches in diameter by 33 ft. long. The perforated screen section was 22 ft. long. The blank end sections were built of ½-inch plate with ⅜-inch high-carbon-steel liner; and the upper or scrubber section was provided with spiral flights as a feed regulator and scrubber. The perforated section was made of ⅜-inch high-carbon or abrasion-resistant steel with ⅜-inch perforations. The stacker was a 30-inch belt, 70 ft. long between pulley-centers.

The jigs are covered by patents granted to H. C. Heath, which have been purchased by Bodinson Manufacturing Co., San Francisco. They are called Bodinson-Heath diaphragm jigs. Instead of the usual eccentric placed below the hutch, the diaphragms are actuated by hydraulic oil-cylinders placed normal to the slope of the hutch, one diaphragm and cylinder on each of the two opposite sides of each hutch. This construction saves head room, allowing a minimum of 36 inches from the floor to the receiving lip of a 42-inch by 42-inch placer jig.

On the Gold Acres dredge, eight rougher jigs, 42 inches by 42 inches, were arranged in two rows of four, one row along each side of the trommel-screen. Between each feed launder and the corre-

[1] Averill, C. V., Gold dredging in Shasta, Siskiyou and Trinity counties: Calif. State Mineralogist's Report XXXIV, pp. 96-126, 1938.

sponding jig was placed a trap for nuggets. The cleaner jig comprised two cells, the first 18 inches by 12 inches, and the second 18 inches by 18 inches. On the first it was planned to make a very high grade of concentrate containing gold and platinum to be removed from the barge for treatment in a laboratory. The product of the second cleaner jig was to be ground in a pebble-mill on the barge, and then to be treated in an amalgamator. The pebble-mill had not yet been installed at the time of our visit. Tailing from cleaner jigs was returned to rougher jigs. The power plant for the jigs consisted of a 10-hp. Westinghouse motor (actually requiring 6½-hp.) driving an oil pump and a rotary valve to give impulses to each jig in succession so that the flow of oil through the pump was practically uniform. Oil pressure varied from 90 to 100 lbs. per square inch, and was automatically controlled.

The main power plant was a D-17,000 Caterpillar diesel engine rated at 130 hp. on continuous load. On an extended engine shaft running in ball bearing pillow blocks was mounted a clutch carrying a V-belt sheave to drive trommel and main pump. A second V-belt sheave drove a 43-kva., 230-volt, Westinghouse alternating current generator with direct connected exciter. The main pump supplied 2000 gallons of water per minute at a 60-ft. dynamic head.

The outfit was operated for only a few months by Gold Acres Dredging Co. in the location given. It was then moved to Trinity County. Further details on its construction are given in an article by H. S. Little.[1]

Gold Chariot Mine in Sec. 7, T. 31 N., R. 5 W., eight miles west of Redding, was worked in 1933 by George Crewdson of Redding. The property includes two mining claims. A quartz vein, 3 ft. to 4 ft. wide, with nearly vertical dip, occurs in the quartz diorite. A maximum width of 8 ft. is exposed where this vein makes a junction with a second vein near the portal of the main adit. The adit is an old one, said to be 165 ft. in length, but it had caved. At the time of our visit, work had been started on cleaning it out. A six-ton mill-run of mixed quartz and country rock from this work was stated to have yielded three ounces of retorted amalgam. Surface cuts on the vein expose it here and there for a total length of 200 ft.

The mill included a Gibson mill of a rated capacity of one ton per hour through a 30-mesh screen, a small crusher, a plate for amalgamation, and a concentrating table of the Wilfley type. A Durant auto engine furnished the power. The Gibson mill was the one formerly installed at the Rattlesnake mine (State Mineralogist's Report XXIX, p. 46).

Greenhorn Mine in Sec. 6 and adjoining sections, T. 32 N., R. 7 W., 23 miles northwest of Redding, near the Redding-Weaverville highway, is assessed to *Greenhorn Mining Co.*, 2135 Sacramento St., San Francisco. Development of a body of heavy sulphide ore at this mine is described herein under the heading of copper.

[1] Little, H. S., Gold Acres to operate jig dredge: Mining and Industrial News, San Francisco, issue of May 15, 1938.

This company obtained one of the development-loans of approximately $20,000 from the Reconstruction Finance Corporation, and spent the money in developing a body of gossan ore that overlies the body of heavy sulphide. It is, of course, a portion of this body of sulphide ore from which the sulphur and most of the copper have been leached by surface waters. Gold to the amount of several dollars per ton of ore remains behind in the gossan. In developing the gossan, the company is said to have discovered beneath it, but still above the sulphide ore, a body of siliceous ore which also contains considerable gold.

Early in 1938, *Consolidated Sierra Mining and Milling Corporation* was organized under Nevada laws with the announced purpose of constructing a cyanide plant of 300 tons daily capacity to treat the gossan ore and the gold-bearing siliceous ore by a process similar to that of The Mountain Copper Company, Ltd.[1] At this time (April, 1939), the plant has not yet materialized.[2] Albert Hanford of San Francisco was in charge of development work.

Hall Bros. Mine (Scharrel) includes four quartz claims in Sec. 2, 11, T. 31 N., R. 6 W., held by H. T. Hall and E. E. Hall of Redding. One placer claim is held also. The property is reached by four miles of mountain road and half a mile of trail from the old town of Shasta. It is said to have been worked in 1912 by Scharrel, and was relocated by Hall Bros. in 1932.

A 39-ft. vertical shaft exposes a 4-inch quartz stringer carrying gold, and this widens to six inches in the bottom of the shaft. To the east, at a distance of 50 ft., is a 35-ft. to 40-ft. open cut, which had a 10-ft. face, but the cut is now partly filled by caving. H. T. Hall states that a small bunch of ore containing $500 worth of gold was removed from this cut, and that a little larger bunch containing $300 was removed from the shaft. Disregarding these rich bunches, the ore is said to be of a very good milling grade. Plans call for sinking the shaft 10 ft. deeper, and drifting to the west, then possibly driving an adit on the vein from a gully roughly 200 ft. west of the shaft. A road to replace the half-mile of trail is planned also.

The old Scharrel workings are 400 ft. east of the shaft on a vein which is stated to show more or less continuous outcrops to indicate that it is the same as the one developed by the present shaft. These old workings consist of a 160-ft. drift-adit, now caved at the portal, on a 1-ft. to 2-ft. quartz vein carrying pyrite and chalcopyrite. A few tons of ore on the dump, rejects from old shipments, are stated to assay $25 per ton in gold. At an elevation 60 ft. lower is a 100-ft. crosscut adit to the vein and 150 ft. of drifting.

Several other veins are known on the property but they have not been developed to any extent. At the extreme west end of the property, about 200 ft. of crosscutting and drifting have been done to develop a 6-inch to 18-inch vein, which is stated to have produced a rich pocket years ago. The west face of this work, where the vein shows its maximum width, is stated to assay $14 per ton in gold.

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[1] Averill, C. V., The Mountain Copper Co., Ltd., Cyanide treatment of Gossan: Calif. State Mineralogist's Report XXVII, pp. 129-138, 1931; also State Mineralogist's Report XXXIV, pp. 312-333, 1938.

[2] Willow Creek Mines, Inc., (a Nevada corporation), H. M. Kuechler, Resident Agent, 206 Sansome St., San Francisco, is building such a plant in the summer of 1939.

Equipment includes a rocker-mill which was at one time used at the Potosi mine. It has a rated capacity of 15 tons in 24 hours when reducing ore from $\frac{3}{4}$-inch size to 30-mesh. It is said to scour the gold so that amalgamation is readily accomplished within the mill. A Buick automobile engine is used to drive the mill. A photograph and further description of this type of mill are contained in State Mineralogist's Report XXX, pp. 270-71, under the name, Hendy's Amador Rocker Quartz Mill.

Hardscrabble or Piety Hill Mine is in Sec. 27, 34, 35, T. 31 N., R. 6 W., at the town of Igo. More than 1000 acres in these sections are assessed to Happy Valley Land and Water Co., Olinda. This company purchased the old mine and its water rights, and now sells the water primarily for irrigation, although some of the dragline dredges of the region are using water bought from the company, and operators of the adjoining Russell mine (which see) bought large amounts of the water for short periods. The Hardscrabble mine was worked on a considerable scale as a hydraulic mine in years earlier than 1880, and a large pit remains as evidence of this work. Apparently anti-debris regulations put a stop to this work, but drifting was continued for a time. The deposit appears to be an old terrace of Clear Creek with a depth of gravel as great as 50 ft. in the hydraulic pit, probably more beyond.

Terbush and Kingsbury of Igo leased the NW$\frac{1}{4}$NW$\frac{1}{4}$ Sec. 34 for a time, and sank a 45-ft. shaft through the gravel to bedrock. From the bottom they did 175 ft. of drifting on the bedrock, which is Copley meta-andesite at this point. Some gold was produced but not enough to pay by this drifting method. These men are prospecting ground farther south for an area that will pay to work by drifting. Miller Bros. of Anderson sank a 41-ft. shaft, also on Sec. 34. The bottom of this shaft was in quartz-diorite bedrock.

Extensive drilling has recently been done on several hundred acres of this property just south of Igo in gravel that probably averages 50 ft. in depth. It is said that the ground is to be worked soon (January, 1939) but the method to be used has not been announced.

Highland Mine comprises 160 acres of patented land and one unpatented mining claim in Sec. 9, 10, T. 33 N., R. 7 W., owned by T. L. Jones, Dewey Hotel, San Francisco. It is 30 miles by road northwest of Redding, the last three miles of which is steep, one-way mountain road, reaching the mine at elevations varying from 3000 ft. to 4000 ft. Good second-growth timber on the property is the right size for mining.

It is one of the early quartz mines of Shasta County, and is said to have had a production of $400,000 in gold in years earlier than 1885, but no actual record of this early production is available at the present time. A large number of dumps indicate that thousands of feet of adits have been driven into the mountain. A quartz vein lies parallel to the slope of the mountain, a little below the top of the ridge. Most of it has been mined off in this vicinity by means of underground and surface workings of the early days. The strike is easterly and westerly, and the dip is 40° south. J. C. Hightower, Route 1, Redding, and M. L. Gill, Anderson, have a lease and option on the prop-

erty. Hightower drove an adit roughly 100 ft. to a faulted segment of the vein, and sank a winze on it. He states that this work exposed a vein 7 ft. wide of ore milling $15 per ton in free gold. He is planning to run a new adit 22 ft. lower in elevation to connect with the winze. Country rock is Bragdon slate with dikes probably similar to the diorite-porphyry found in other French Gulch mines to the south; but here it is quite fine in grain, and is much decomposed and stained by oxides of iron near the surface. The ore occurs in lenses, pinching and swelling. Pannings taken from some of the old dumps and from various points on the surface near the vein indicate a gold content of several dollars per ton in this loose material. Whether the tonnage is sufficient to warrant working the surface can be determined only by a systematic campaign of sampling. Workings driven in recent years are in loose ground, where blasting is not necessary, but spiling must be driven. Practically all underground workings are now closed, and the vein is to be seen only on the surface.

Highland Lake Mine includes nine unpatented mining claims in Sec. 12, T. 37 N., R. 6 W., held by Phil Munko, Castella. It is about 15 miles northwest of a point on the Pacific highway near Gibson by a poor mountain road. Country rock in the vicinity is all basic, with much alteration to serpentine. Some chromite has been produced in the immediate vicinity. At the point where recent prospecting has been done, a quartz vein with a width of several feet outcrops prominently. The quartz is of a glassy variety, and has not been found to contain gold. However, a shear zone in the country rock on one of the walls of this vein has yielded specimens of green, sheared country rock that are plentifully sprinkled with visible free gold. Prospecting is being continued on this shear-zone with cuts and shallow shafts when weather will permit. The elevation is 6000 ft. and snowfall is very heavy.

Horstman Property includes two unpatented mining claims in Sec. 9, T. 31 N., R. 5 W., held by A. Horstman, Redding. They are four miles southwest of Redding by a dirt road. Horstman has prospected a quartz vein from a few inches to a foot wide, in Copley meta-andesite, by means of shafts from a few feet to 14 ft. deep along 100 ft. of the strike. The vein strikes S. 50° W. and has a nearly vertical dip. Some of the quartz has rather abundant galena and pyrite scattered through it in small crystals. Much of the quartz has been leached by surface waters, and iron oxides remain in the cavities formerly occupied by sulphides. Good assays in gold are said to have been obtained.

Igo Mining Corporation—see Russell Mine.

Igo Placer Mining Company holds 30 acres of land in Sec. 34 (?), T. 31 N., R. 6 W., at the town of Igo. The tract was formerly a portion of the Russell mine (which see), and was purchased from F. H. Russell. M. D. Baker of Redding leased the property for a time, and made several short runs with a 'dry land dredge'. Gravel was mined from a bank about 20 ft. high with a P. & H. gasoline shovel of the dipper stick type with a bucket of one cubic yard capacity. The washing plant was of timber construction built on heavy timber skids so

that it could be pulled ahead by means of a cable attached to the shovel. Gravel was dumped into a hopper located only a few feet above bedrock by the shovel, and was raised to the feed-end of the trommel by a belt conveyor. Oversize from the trommel was stacked by a second belt conveyor, and undersize was washed in riffle sluices, then discharged by a sluice mounted on trestles resting on the ground. All power was furnished by gasoline engines. The outfit was later moved to a point on Clear Creek, Sec. 34, T. 32 N., R. 6 W.

Mammoth Mine in Sec. 32, T. 34 N., R. 5 W., four miles northwest of Kennett, is owned by United States Smelting, Refining and Mining Company. This mine supplied a large part of the copper ore formerly treated in the smelter at Kennett, which had a capacity of 2200 tons daily. This ore contained roughly $2 per ton in gold and silver. Outcrops of the orebody have been converted to gossan by oxidation and leaching by surface waters, but the amount of gossan is not nearly so great as that at Iron Mountain, where The Mountain Copper Co., Ltd., recovers gold from 700 tons of it daily. The gossan on the Mammoth has been extensively sampled for the owners, who employed a crew of men for several months for this purpose. So far as is known, the company is not planning to mine the gossan. Recent underground development by this company is mentioned under the heading of zinc.

Menzel Mine comprising the Scottish Chief and Santa Clara patented claims, in Sec. 31, T. 33 N., R. 5 W., in the Flat Creek Mining District, is assessed to Wm. Menzel Co., c/o Wm. B. Menzel, Redding. Old workings on the surface, consisting of cuts, tunnels, and an 80 ft. shaft, have caved. Some production was made from these about 1880 or 1890. By means of outcrops and these old workings, the vein can be traced for at least 1000 ft, on the surface. Widths vary from a fracture containing no quartz to a maximum of 6 ft. of quartz, with some country rock between strands of the vein. The strike is S. 85° W., and the dip 60° to 70° to the south. A fine-grained, basic, pre-mineral dike a foot or two in width accompanies the vein. The dike has been intruded into quartz-diorite.

A main adit level, roughly 150 ft. below the outcrop, crosscuts in the hanging wall of the vein for 600 ft., then turns and follows the vein to the west for 250 ft. The last 50 ft. of this drift was driven by Otto Reif and associates, who were leasing the property and had a crew of six men at work in 1934. They started on a width of 8 ft. of quartz, but toward the face the quartz pinched, so that little was showing but the dike. A fault, probably with only a few feet of displacement, showed in the face also. The same condition was encountered on the intermediate level, 35 ft. above, and the vein was followed for 100 ft. beyond.

Reif built a mill consisting of a crusher, 6 inches by 8 inches, five stamps of 850 lbs. each, plates for amalgamation, and a table of the Wilfley type for concentration of sulphides, which are rather plentiful in the ore. Power was furnished by electric motors of 5 hp. and 20 hp. connected to lines of the Pacific Gas and Electric Co. A few short runs of this mill were made.

Merry Mountain Diggers, a corporation, of which Sidney B. Wood, 9172 Sunset Boulevard, Hollywood, is president, and E. G. Chandler, 723 Balboa Building, San Francisco, is secretary, controls 2120 acres of land in Sec. 34, 35, 36, T. 33 N., R. 7 W., and Sec. 1, 2, T. 32 N., R. 7 W. The property is on the Redding-Weaverville highway at a distance of 17 miles from Redding. Carl Harding, Box 846, Redding, took over the management early in 1938 from a former manager who had spent a large sum of money on equipment.

The prevailing formation is the Copley meta-andesite, into which dikes of rhyolitic material have been intruded. A few quartz stringers occur also. The plan was to mine surface material from the side of the mountain, on a large scale, with power shovels, and to recover gold by amalgamation and by gravity concentration on Wilfley tables. Coarse material was first rejected by a trommel (Bodinson) with $\frac{3}{8}$-inch holes. Under the first manager, a large stationary plant of this kind was built, and two test runs of a total of roughly 20,000 tons were made. The longest run was 18 days, and about 1000 tons per day were handled during that time. The property has been idle during practically all of 1938.

Metallic Extraction and Engineering Co., 1028 Fourth and Pike Building, Seattle, Washington, installed an experimental plant at Cottonwood, where R. R. Couls was local manager. The plan was to collect sands rejected at time of cleanup by dredges, particularly dragline dredges, and to further treat the sands for recovery of gold and platinum. A concentrate was first made on a Wilfley table, then dried and heated, and finally passed through molten lead. The pot of lead was heated electrically, and was equipped with a mechanical stirring device designed to force the sand to the bottom of the pot. Siliceous material then floated to the surface of the lead, and was skimmed off as tailing. Several runs of a few tons each were made with this equipment. Couls states that a larger plant is to be built at Junction City, Trinity County.

Midas Mine is in Sec. 3, 4, 10, T. 29 N., R. 10 W., at Harrison Gulch (Knob postoffice), in the southwestern corner of Shasta County, 52 miles from Redding. Very extensive gold mining was carried on here for years. According to J. B. Moore of Knob, the present owner, the records show a gross production of over $4,000,000. The mine has not been operated recently, and most of the equipment has been removed. References to former reports on this mine are given in the accompanying table of mines.

Milkmaid Mine in Sec. 16, T. 33 N., R. 7 W., three miles northwest of French Gulch, is assessed to Western Exploration Co., c/o Grant Smith 657 Mills Building, San Francisco. For several years, until given up recently, it was operated by J. H. Scott Company, Merchants Exchange Building, San Francisco. The mill was reconditioned and partly rebuilt, and other buildings were repaired to accommodate the crew of 20 men. A new concrete foundation was placed under the 10-stamp battery of 1150-lb. stamps. Other equipment in the mill included two plates for amalgamation, 5 ft. by 12 ft., six Kraut flota-

tion cells, Wilfley table, 16-ft. thickener and an Oliver filter for dewatering concentrates. To regrind tailing, of which several thousand tons from an old tailing-pond were treated, a 5-ft. Huntington mill was installed. Below it was a plate for amalgamation, 5 ft. by 12 ft. All equipment was electrically driven.

In the mine, on the Geiser adit level, 1800 ft. of workings were cleaned out, and track and pipe were relaid. Part of this was retimbered. A new crosscut was driven 56 ft. to reach a vein, on which 75 ft. of drifting and 60 ft. of raising were done. The mixed quartz and diorite porphyry of this vein was said to make a good grade of milling ore. In another place on this level, 30 ft. of crosscutting and 115 ft. of drifting were done to develop an 8-inch vein. Dips of these veins are steep, averaging about 70°. A combination shaft and raise from this level was cleaned out and retimbered where necessary to put it in good condition. The shaft part goes down 200 ft. and some new work was done on the bottom level. The raise part goes up 150 ft. to the Franklin level, where a new 30-hp. electric hoist was installed. Several hundred feet of old raises were re-opened with the idea that much ore that had been left behind when gold was $20 per ounce could be profitably treated in the remodeled mill with gold at $35 per ounce. Mine equipment included two 12-inch by 12-inch compressors driven by two 40-hp. electric motors and two pumps with 10-hp. motors. Older workings of the Milkmaid and Franklin mines are described in State Mineralogist's Report XXII, pp. 175-76.

Miners' Group of Mines (Brunswick) is in Sec. 19, T. 33 N., R. 7 W., on the mountain west of French Gulch, at an elevation of 4000 ft. The distance from Redding is 25 miles, and the last few miles are steep mountain road. This mine was located in 1879, and references to the old work under the name of Brunswick are given in the accompanying table of mines. For several years development work has been carried on by the owners, Rossi and Rossi, French Gulch.

The black Bragdon slate is intruded by a dike of diorite porphyry similar to those found elsewhere in the French Gulch District. Quartz veins carrying gold and auriferous sulphides cut through both formations. A new adit has been driven at an elevation approximately 150 ft. lower than the lowest of the old Brunswick levels. At a distance of 1100 ft. from the portal, a quartz vein about a foot wide is being developed. Country rock on both sides of the vein for a width several times that of the vein is stated by the operators to be commercial ore. Strike is N. 80° E., and dip is 45° north. The hanging wall is slate and the footwall is diorite porphyry. At this distance from the portal, the new adit is said to be farther in the mountain than any of the old workings, and backs are said to be 450 ft. On the new level crosscutting and drifting of 400 ft. have been done in addition to the 1100 ft. already mentioned. A raise has been driven from the new level to an old level, 150 ft. higher, and intermediate levels at 50 ft. and 100 ft. above the new level total 200 ft. of drifts and crosscuts. Some ore has been developed here also, chiefly mineralized diorite porphyry. Mine equipment includes an Ingersoll Rand compressor of one drill capacity, driven by an electric motor.

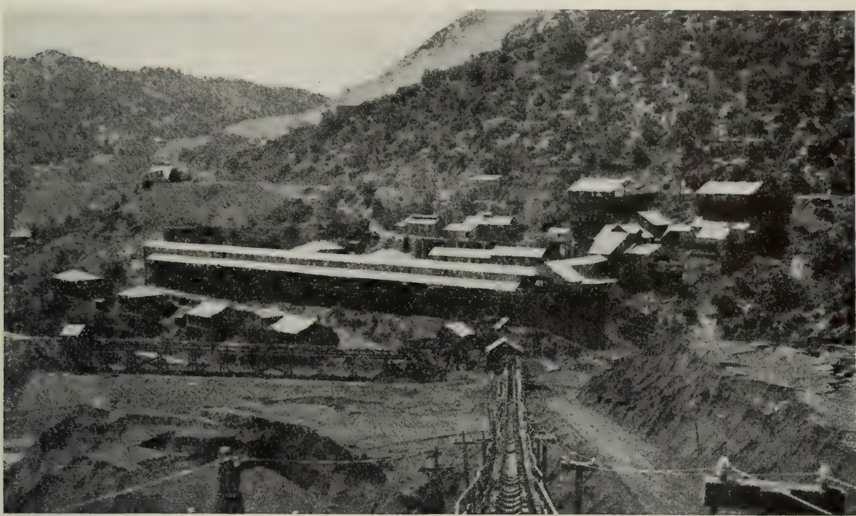
Mill at Miner's Group of Mines.

Operation of a new mill for eight hours per day was started in August, 1938. It includes a primary jaw-crusher, 6 inches by 12 inches, crushing to one-inch size; ball mill, 3 ft. by 4 ft.; rake type classifier; Pan American jig, 12 inches by 12 inches; two Kraut flotation cells, 27 inches by 27 inches; and a Wilfley table, 5 ft. by 16 ft. Rated capacity is 25 tons per day of 24 hours. Electric power is bought from Pacific Gas and Electric Co. G. N. Keefauver is in charge of the mill, and a total of five men are at work in mine and mill.

Minnesota Mine includes 34 acres patented, M. S. 3585, in Sec. 1, 2, T. 32 N., R. 6 W., 13 miles northwest of Redding. The main adit level starts in a shearzone in a dike, probably alaskite porphyry, and follows it for 300 ft., at which point quartz starts to come in; and it widens to 4½ ft. at the 500-ft point. Beyond this is a caved stope, which appears to have been 7 ft. wide. The ore is quartz carrying pyrite and chalcopyrite with some free gold. The strike is N. 75° to 80° W., and the dip is 70° N. The general formation in the vicinity is quartz diorite intruded by dikes. Apparently some production was made from stopes above this level in 1891 or 1892.

In 1934, the property was operated by *Cambria Copper Company, Ltd.*, of which E. H. Bridgman, North Vancouver, British Columbia, was president, and Walter H. Smith, Suite 610-12, 402 Pender Street West, Vancouver, B. C., was secretary. Work consisted largely of cleaning out and retimbering old workings. The main adit level was

cleaned out for its entire length of 1200 ft. The vein pinches near the face to a width of about a foot. Stephen Girard of Matheson is the owner of the property.



Cyanide Mill, the Mountain Copper Company, Ltd.

The Mountain Copper Company, Ltd., in Sec. 34, 35, T. 33 N., R. 6 W., at Iron Mountain (Matheson postoffice), 17 miles northwest of Redding, conducts the largest mining operations in Shasta County. The newly remodeled cyanide plant continues to treat 750 tons of gossan-ore daily for the recovery of gold. Full details on this plant have recently been published by this division.[1] The main change that has been made recently is the substitution of tractors for trucks on the haul from the quarry to the mill. A Caterpillar tractor and 'buggy' hauls 30 tons to a load, and this has materially reduced cost of transportation. Other activities of this company are mentioned herein under the headings of iron and pyrite. References to former reports describing copper mines of this company are given in the accompanying table of mines.

National Mine (Veteran or Forbes) is a group of unpatented claims in Sec. 23, T. 33 N., R. 5 W., 10 miles north of Redding, held by Mrs. G. M. Sleezer of Redding. It is an old group originally located in 1869, and at one time a 10-stamp mill was operated, but this has been removed. Later shipments were made to smelters, and total production is said to have amounted to $200,000 in gold. A 1200-ft adit and a 700-ft winze from it have been inaccessible for 25 or 30 years. Various lessees have opened up some ore on the surface at a point that is supposed to be farther north than any of the old workings. A shaft has been put down some 50 ft. on a 2½-ft. vein of white quartz containing rather abundant pyrite. In 1934, three of the claims were leased

[1] Averill, C. V., The Mountain Copper Co., Ltd., Cyanide treatment of gossan, State Mineralogist's Report XXXIV, pp. 312-330, 1938.
An article of the same title described an earlier method of treatment: State Mineralogist's Report XXVII, pp. 129-138, 1931.

to Carey Allan Thompson, who shipped several truckloads of ore from this shaft to smelters.

Niagara Summit Mining Co., c/o W. D. Tillotson, Box 68, Redding, is in Sec. 6, 7, 8, 17, 18, T. 33 N., R. 7 W., in the French Gulch District. A large amount of work has been done on the holdings, most of it on the Yosemite claim, and past production is estimated roughly at $1,000,000. In an upper level called the O'Neil tunnel, which runs northwesterly through the center of the Yosemite claim, a small segment of the Niagara vein was found about 200 ft. southwest of the center of the claim. The old 10-stamp mill on this property is on the same road that reaches the Washington and Sybil mines, and is near the northwest corner of Sec. 17. The main adit level from which recent development work has been done, called the Barnes level, is at an elevation 520 ft. lower than most of these old workings. The portal is in Sec. 8, a mile by trail up the Right Fork of Clear Creek from the Milkmaid mine. No road has been built to it. The Barnes adit starts near creek-level, cuts through the northeast corner of the Yosemite claim, and runs southwest through the claim. A little ore was found in the southwestern part. The adit continues into the north part of the Comet claim.

Patented ground consisting of the Coleman Quartz Mine, 161.95 acres, and the SE¼ Sec. 36, T. 34 N., R. 8 W.; also the unpatented Bacon, Nebraska, Michigan, Utah, Barney Coleman, Badlam, Jumbo Extension, Missouri, Illinois, Ohio, and Iowa quartz claims; also a 7.5 acre leasehold were leased in December, 1937, to Charles W. Plumb.

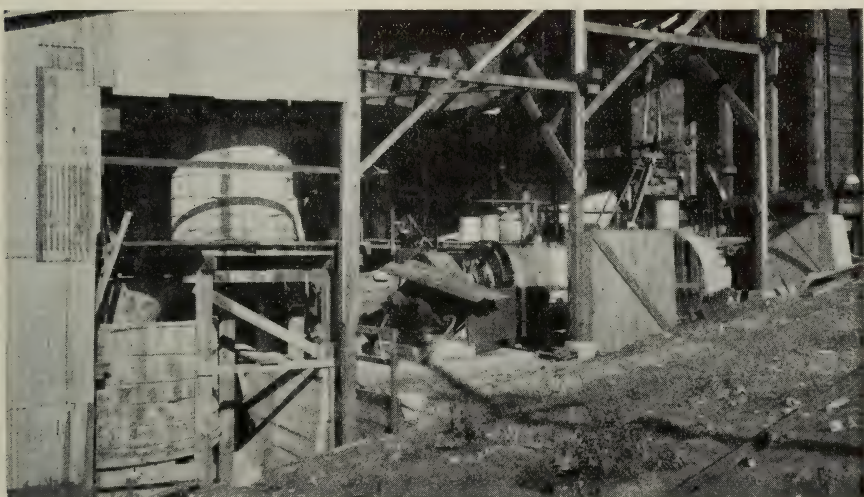
During most of 1938, Plumb had a crew of about seven men at work driving a crosscut through a dike of diorite porphyry to pick up a segment of the vein on the Barnes adit-level. John Mackey, French Gulch, was foreman. Compressed air was furnished by a 75-hp. compressor driven by power from lines of the Pacific Gas and Electric Co. This work is said to have been financed by *Empire Star Mines Company, Ltd.*, which is controlled by *Newmont Mining Corporation.* References to earlier reports on this mine are included in the accompanying table of mines.

Old Diggings District in Sec. 33, 34, T. 33 N., R. 5 W., and Sec. 3, 4, 10, T. 32 N., R. 5 W., 10 miles north of Redding, contains the Texas, Mammoth, Central, Reid, Evening Star, Walker, and Calumet mines named in order from north to south. Each of these is a group of patented claims with a record of past production of gold from quartz veins. Descriptions of each, with a claim-map of the district, and vertical projections of the Reid and Texas have been published in State Mineralogist's Report XXIX.[1] These are not repeated here. About 1890, a stamp-mill was operated at the Texas for a number of years, but the recovery of gold was probably not very high because a very large percentage of the gold is in the sulphides, chiefly pyrite. From 1907 to 1919, large tonnages of ore were mined from the Reid to furnish silica for the Mammoth smelter at Kennett. This made a very favorable market for the ore because payment was made for both silica

[1] Averill, C. V., Gold deposits of the Redding and Weaverville quadrangles: Calif. State Mineralogist's Report XXIX, pp. 3-73, 1933. A map showing areal geology and locations of gold mines is included.

and gold. The Reid is the deepest mine of the district, being developed to a vertical depth of about 1000 ft. After the smelters shut down, little was done in this district until recently, although the Reid mine was unwatered and sampled by H. W. Stotesbury in 1923. An abstract of his report is given in the publication cited. Harvey Sallee later shipped some ore from the mine but allowed it to fill with water again in 1925. A main adit drains the shaft to the 250-ft. level. The mineralization of the district is associated with a rhyolitic dike intruded into the Copley meta-andesite as noted in the section on geology under the heading of gold above.

Schwab and Taylor, P. A. Schwab and G. Cleveland Taylor, Box 958, Redding, are operating the Texas, Mammoth, Central, Reid, and Evening Star mines. The Walker has been operated recently under different management and is described separately herein. The fifth or main working level of the Texas has been cleaned out to the 1500-ft. point. Work has been started at the portal of the lowest adit of the Central to reopen it. Retimbering has been started at the Reid shaft and must be continued for 250 ft. to water level. A 350 cfm. compressor is being reconditioned and will be driven by a 75-hp. Caterpillar diesel engine. Other machinery is being reconditioned here also.



Flotation mill at Schwab and Taylor Mine.

An ore-shoot has been found in old workings near the apex of the Evening Star vein near the point where it crosses the property-line into the Reid. The main Evening Star adit, roughly 300 ft. lower in elevation, is being driven north at the 1500-ft. point to reach this ore-shoot. Taylor figures that he has 125 ft. yet to go (January, 1939). The strike at the apex is north and south, and the dip is 66° east. Ore-shoots are believed to have a steep rake to the north. A compressor driven by a 50-hp. Caterpillar diesel engine is used here. Dump-ore from the Evening Star is loaded on a 3-ton truck by a $\frac{3}{4}$-yard power shovel at an average rate of 175 tons per day.

Ore is treated in a new mill of a rated capacity of 100 tons per day containing a crusher, 10 inches by 14 inches; 4½-ft. by 14-ft. ball mill driven by a 100-hp. electric motor; Dorr-type duplex classifier; Pan American jig; six Minerals Separation flotation cells, each about 2 ft. square, used as roughers; one Groch flotation cell, 6 ft. by 6 ft., used as a cleaner; and a Wilfley pilot table. Roughly half of the dump ore is rejected by a revolving trommel-screen, from which ore of about 1-inch size is elevated by a belt conveyor to the fine-ore bin at the mill. Total connected load of electric motors in the mill is about 300 hp. The dump-ore has been subjected to weathering for many years, and difficulty in making a good recovery is experienced because the sulphides are tarnished. This ore contains practically no free gold.

References to earlier reports on these mines are contained in the accompanying table of mines.

Phoenix Mine is a single unpatented quartz claim in Sec. 15, 16, T. 32 N., R. 6 W., held by Henry Roberts of Schilling. The location is about a quarter of a mile north of the Redding-Weaverville highway at a point one mile east of Whiskytown (Schilling postoffice). It is an old property, which Roberts states was equipped with a five-stamp mill in 1886, and which kept this mill supplied with ore for about two years. In 1893, some of the siliceous ore was hauled to the Bully Hill smelter.

A quartz vein strikes easterly and westerly, and dips 65° north. It has a width of about 14 ft., and Roberts states that it has been traced for the full length of the claim. The old workings seem to be confined to a shorter distance near the center of the claim. Most of them are closed, but the vein is well exposed in one open cut. At a point on the hill, 70 ft. lower than this cut, is an adit, which Roberts states is 700 ft. or 800 ft. long, following the main vein for the entire distance. It is now closed at a point 90 ft. from the portal by rock from a broken chute. On the surface a branch vein striking N. 35° W. and a vein parallel to the main vein are seen. Each has a width of 3 ft. and the dips are the same as that of the main vein. The main vein is said to assay $4 per ton in gold, and bunches of ore of much better grade are occasionally found. The mine has not been worked recently.

Pilot Dredging Company, Ltd., with Charles M. England of Redding as manager operated a dragline dredge during part of 1938 at the head of China Gulch, in Sec. 5(?), T. 30 N., R. 5 W., 10 miles southwest of Redding. The outfit is similar to the all-steel equipment built by Bodinson[1] Manufacturing Company, San Francisco, except that it is very small in size, being built on only two pontoons. A space about two feet in width is left lengthwise of the center between the pontoons. The dragline bucket used is of a capacity of only half a cubic yard. All power is furnished by gasoline engines. The machinery occupies much less space than the usual dragline dredge, and can be used to work smaller and shallower gravel deposits. Costs per cubic yard are no doubt higher.

[1] Described by Averill, C. V., Gold Dredging in Shasta, Siskiyou and Trinity Counties: Calif. State Mineralogist's Report XXXIV, 96-126, 1938.

Pilot Dredging Co.

Potosi Mine in Sec. 22, T. 31 N., R. 6 W., at Muletown, 12 miles west of Redding, is assessed to Potosi Land and Mining Co., c/o Abner Baldwin, 304 Foothill Boulevard, Oakland. This is an old property of 47 acres of patented mining claims, from which some production was made about 1890. Workings at that time included a 90-ft. shaft at the south end of the property, where an ore-shoot 100 ft. long and 4 inches to 16 inches wide, said to be high-grade ore, was stoped out. Another shoot of good ore was discovered farther north, near the center of the property, by Frank Gelhaus of Redding in 1932. *Spring Gulch Mining Co.,* with Dr. Chas. Harvey of Marysville in charge, then operated the mine for a year or two.

Muletown Consolidated Mines, Inc., has recently operated this Potosi mine. W. W. Stoll, 211 Maritime Building, Seattle, Washington, was president; and E. L. Vinal, 1618 Northern Life Tower, Seattle, Washington, was managing engineer. R. H. DeWitt of Redding was local foreman. A new two-compartment shaft, 5 ft. by 10 ft. was sunk about midway between two older shafts, which are mentioned in State Mineralogist's Report XXIX, pp. 44-45. The new shaft exposed a nearly vertical quartz vein varying from a few inches to 2 ft. in width. Drifts of 230 ft. to the north and 150 ft. to the south were driven at the 52-ft. level. The drift to the north holed into workings from one of the older shafts, but the drift to the south developed some ore. Some ore was stoped at the Great Western Mine (see State Mineralogist's Report XXIX, p. 29) just to the north, from a stope 100 ft. long by 35 ft. high, on a 6-inch to 18-inch vein.

Ore was treated in a mill of 30 tons rated capacity per 24 hours, consisting of the following: No. 3 gyratory crusher crushing to 1-inch size, belt conveyor to fine ore bin, Lane mill with 40-mesh screen, Titan 4-ft. rotary amalgamator, 8-inch by 4-ft. plate for amalgamation in launder, one No. 6 Wilfrey table. Power for the mill and for an air-compressor was furnished by oil-engines. Much of the machinery was removed in September, 1938, and the mine has since been idle.

Reid Mine—see Old Diggings District.

Richstrike Gold Mines, Ltd., a corporation controlled in Vancouver, British Columbia, operated the Boswell mine in Sec. 7, T. 31 N., R. 5 W., seven miles west of Redding, in 1934 and 1935. A mill of 50 tons rated daily capacity containing flotation machines and a ball mill driven by Caterpillar diesel engines was built. Later a lease and option were obtained on the Yankee Jack mine, which has been described in State Mineralogist's Report XXIX, pp. 57-58. Ore developed between the 100-ft. level and the 200-ft. level of that mine was extracted and hauled to the Boswell for milling. The Yankee Jack was then allowed to revert to the original owner, and the mill was sold to Schwab and Taylor, who are operating in the Old Diggings District, 10 miles north of Redding.

Russell Mine (Lost Channel) is a placer property near Clear Creek, just south of Igo, in Sec. 34, T. 31 N., R. 6 W., and Sec. 4, T. 30 N., R. 6 W., 12 miles southwest of Redding, at an elevation of 1100 ft. The deposit is a continuation of the Hardscrabble (which see) and is probably a portion of an ancient terrace of Clear Creek. In the Russell property it has a width from half a mile to a mile. The owner is F. H. Russell of Redding, who holds 210 acres patented and additional mining locations to make up a total of 500 acres. The present drainage of upper Dry Creek cuts across this old terrace in a southwesterly direction. Prospecting of the gravel by means of 12 shafts and about 38 drill-holes is stated by Russell to have indicated an average value per cubic yard of $10\frac{1}{3}$ cents for an average depth of 45 ft., with gold at \$20 per ounce. The depth to bedrock varied from 18 to 80 ft. Bedrock is largely quartz diorite, in some places decomposed; but a sandstone bedrock (Cretaceous) is found on the southern part of the holdings.

Western Contracting Co.

In 1933, *Western Contracting Company,* with Fred Galeno of Seattle, Washington, in charge, operated the property with gasoline power shovel and trucks. Operators stated that 125 cubic yards were moved per hour for eight hours per day, at a cost of roughly 20¢ per cubic yard. The mining was said to be following a particularly rich channel containing 35¢ to 50¢ per cubic yard in gold. Gravel was excavated with a $1\frac{1}{4}$-yard power shovel, and was hauled in three 5-ton White trucks to a stationary washing plant, a few hundred yards away. Coarse tailing (cobbles and boulders) were dumped into a bin, from which they were hauled away by a fourth truck. The washing plant consisted of a revolving trommel-screen similar to those used on dredges, with holes of about $\frac{1}{2}$-inch at the upper end and 1-inch at the lower end. Fines passing through the screen were washed in a sluice equipped with riffles containing quicksilver. Water for washing was purchased from Happy Valley Land and Water Co. Work was carried on for a few months in a cut with a 40-ft. face, with a crew of 15 men. Apparently most of the deposit is too low in grade to return a profit from this method of working.

Igo Mining Corporation.

In 1935, *Igo Mining Corporation,* a Delaware corporation, operated the Russell property, and was said to control adjoining land of the Happy Valley Land and Water Co., to make up a total of 2200 acres. Delaware Registration Trust Co., 900 Market Street, Wilmington, Delaware, was agent for Igo Mining Corporation, which maintained offices for a short time at Lorenz Hotel, Redding, at 662 Russ Building, San Francisco, and at 120 Broadway, New York City. The local manager was J. F. Stratton, who also managed Shasta Hydraulic Gold Company at Trinity Center, Trinity County. The latter company acquired the old Estabrook property, and did a little hydraulic mining there. At Igo, three giants with nozzle openings of 4 inches to $5\frac{1}{2}$ inches were supplied with water from the ditch of Happy Valley Land and Water Co. through three 15-inch pipes attached to 3500 ft. of 24-inch pipe from the reservoir. A second line of 3500 ft. of 36-inch and 34-inch

pipe was later installed. The reservoir was a new one on the ridge just above the mine, giving a head of 149 ft. This operation lasted only a few months, and the property has since been idle.

St. Jude Mine (formerly Vogt or Philadelphia and Roosevelt) in Sec. 17, T. 33 N., R. 7 W., adjoining the Washington mine near French Gulch, has been acquired by A. P. Robillard of French Gulch, who is operating it with a crew of from three to six men. He has located a third claim, and the property now comprises the Philadelphia, the Roosevelt, and the Santa Maria claims. A 170-ft. crosscut adit exposes an oxidized quartz vein carrying free gold. The strike is easterly and westerly, the dip is 60° north, and the width varies from 6 inches to 4 ft. An ore-shoot with a flat rake to the west has been developed for a length of 120 ft. and has been partly stoped out. To the west the vein splits, one part following a contact between slate and diorite porphyry, the other having both walls of diorite porphyry. Both portions carry shipping ore, and a winze sunk 20 ft. on one of them is still in good ore at the bottom. Ore is mined by hand and a carload of 50 tons is shipped each month to the smelter at Tacoma, Washington. The ore is sacked for shipment, and the grade is kept over $100 per ton. An 80-ft. raise on the vein from this main level reaches the surface.

A survey has been completed for a level 140 ft. lower in elevation to start from a point on the road between the Washington and Niagara mines, and to follow a contact between slate and diorite-porphyry thought to be the same as that exposed in the western part of the present level. This lower level is expected to reach the ore at a distance of 300 ft. from the portal. Two other veins that have been productive exist on the property.

Summit Mine includes a group of eight claims in Sec. 17, 18, 19, T. 33 N., R. 7 W., controlled by L. W. Wheeler and partners of French Gulch. It is near the summit of the Tom Green grade running from French Gulch to Trinity County. Older workings on this property have been described in State Mineralogist's Report XXIX.

G. C. Berker has recently operated it under lease and option. At a point in the Barnes level, 234 ft. from the portal, he drove a 250-ft. crosscut to reach the vein developed in the Wheeler level, and stoped some ore between these two levels, which are 30 ft. apart. At the time of our visit, most of the work in the mine was being done on the Galena level, which is 208 ft. above the Barnes on the dip of the vein. Drifting was to be done, and some ore from old stope-fills was to be milled. At a point in the Barnes level, 900 ft. from the portal, a winze had been sunk 90 ft. on the vein at an average dip of 43° east. L. M. Brady was mine-foreman.

A new mill had been started about July 1, 1938. It contained a gyratory crusher and rolls for crushing in two stages, followed by a 6-ft. Huntington type mill driven at 80 rpm. Capacity was stated to be 35 tons to 55 tons per day ground to 35-mesh. Treatment was by amalgamation and gravity concentration. A 4-ft. by 4-ft. plate for amalgamation below the Huntington mill was followed by a rotating Titan amalgamator containing six plates, each 6 inches by 4½ ft. Below

this was a Titan jig, 12 inches by 32 inches, actuated by mechanically driven diaphragms, then a No. 6 Wilfley table, middlings from which went to an 8-ft. table of similar design but made by Straub. Below the tables were two sluice-boxes, each 17 inches wide by 12 ft. long containing English corduroy. Operators stated that 60% of their recovery was made by amalgamation, the balance in a concentrate assaying $100 per ton in gold or more. H. F. King was in charge of the mill. Electric power from lines of the Pacific Gas and Electric Co. was used throughout the plant. The total crew in mine and mill at the time of our visit was 18 men.

Sybil Mine (Shasta Hills, Accident, Anaconda) is a group of 20 unpatented claims in Sec. 7, T. 33 N., R. 7 W., of a total area of 360 acres, held by L. Von Krusze of French Gulch. It is 26 miles from Redding by road, 18 miles highway, balance mountain road. The deposit is typical of the French Gulch district—quartz veins associated with dikes of diorite porphyry in slate. The quartz contains pyrite, sphalerite, galena, arsenopyrite, and free gold. Mining has been done from several adit-levels covering a vertical range of 200 ft. above the sixth level, the main adit; also from a winze reaching a depth of 150 ft. below the sixth level. Another adit, 540 ft. lower in elevation, is caved at the portal. It is said that this must be driven 400 ft. farther to reach the vein-system. Equipment includes a 12-inch by 12-inch Rix single-stage compressor, 15-hp. electric hoist, 5-stamp mill of 1200-lb. stamps, other machinery, and various buildings. Electric power from lines of Pacific Gas and Electric Co. was used. Only small-scale work by the owner with at times one other man has been done recently. References to earlier reports are contained in the accompanying table of mines.

Tabowie Mines, Inc., H. W. Friedrich, president, Stanley G. Kramer, secretary, San Francisco, operated a property in Sec. 10, 15, 16, T. 33 N., R. 7 W., half a mile north of French Gulch during part of 1933. C. E. Wood was in charge. The NE¼ and the W½SE¼ Sec. 15 was acquired from Southern Pacific Land Co.; the Mary Bell, Cash Boy, Little John, Little Billy, Fairview, in Sec. 10, and Roosevelt No. 1, 2, 3, 4, 5, in Sec. 15, and Hattie Bell and Bluebird in Sec. 15, 16, were optioned from Robert DeJournal, Tom Moon and J. T. Williams of French Gulch. An adit was started at an elevation roughly 100 ft. higher than Clear Creek, at a point half a mile north of French Gulch, and according to Wood it was to be driven a mile to cut through the holdings. At the time of our visit, in the summer of 1933, it had been driven 400 ft. on a course of N. 22° W. through Bragdon slate cut by dikes of a fine-grained quartz-diorite. Several quartz stringers a few inches in width had also been cut. The property has been idle for practically all of the time since 1933.

Texas—see Old Diggings.

Thompson Property, 480 acres of patented land, in Sec. 34, T. 33 N., R. 4 W., is owned by the estate of Sarah E. Thompson, George W. Thompson, executor, Redding. It is 10 miles northeast of Redding by a good road, half highway, half dirt road. Some prospecting was done

here, on the east fork of Stillwater Creek, between 1890 and 1900, and a shaft of unknown depth was sunk in the creek-bottom. White quartz carrying much chalcopyrite is found on the dump. Outcrops of gossan occur here and there over a tract half a mile long and several hundred feet wide. Much of the intervening ground is covered by overburden. Paul McEwen of Redding, who is leasing the property, states that the average of 10 samples of the gossan was $5 per ton in gold. Country rock is quartz-diorite-porphyry intruded into McCloud limestone, probably also into the Dekkas andesite.[1]

Tom Green Mine is an old property in Sec. 17 (?), T. 33 N., R. 7 W., in the French Gulch District adjoining the Summit mine. Four claims are held by Henry Carter, C. C. Fox and others of French Gulch. Production was made from several adit levels in the years from 1890 to 1914. In 1937, it was leased to Homer D. Erwin and Stanley Erwin, who drove a new adit-level at an elevation 280 ft. lower than the lowest of the old ones. The new adit runs 250 ft. in a southeasterly direction, then 250 ft. in a southwesterly direction. It was expected to reach a point vertically under the old Tom Green stopes if it was continued for 150 ft. to the southwest. This was based on information taken from old maps, which are not very satisfactory. The work to the 500 ft. point was practically all in the Bragdon slate. At another place a 20-ft. adit was driven on the contact between a diorite-porphyry dike, 100 ft. in width, and the slate. Some quartz was found on this contact. A quartz stringer a few inches wide from which some free gold could be panned was struck at the 450-ft. point in the long adit. All work was done by hand.

Triple S Placer Mine includes 15 acres on the west side of the Sacramento River and 25 acres on the east side, at a point 33 miles north of Redding, held by location by E. W. Thwing, for whom Geo. E. Morrill, Attorney at Law, 116 Hamlet Street, Los Angeles, is agent. The property has not been visited.

Uncle Sam Mine in Sec. 1, T. 33 N., R. 6 W., Sec. 6, T. 33 N., R. 5 W., and Sec. 36, T. 34 N., R. 6 W., five miles up Squaw Creek from a point near Kennett, is the property of the Dakin Co., c/o C. C. Dakin, Redding. It is one of the well-known, old gold-quartz mines of Shasta County, having produced more than $1,000,000 in a number of years earlier than 1913, when it was operated by Sierra Buttes Mining Co. Descriptions and maps of these old workings are given in State Mineralogist's Reports XIV and XXIX. A small amount of development work was done by *Vera Mines Corporation* in 1936-1937.

Walker Mine (Utah & California) has been purchased by *Dowling Mining and Investment Co.,* of which the name was later changed to *Star Gulch Mining Co.,* a Missouri corporation. A. W. Altvater is president, and Geo. H. Stephens, 2920 Cass Avenue, St. Louis, Missouri, is secretary. James J. Dowling was manager at the mine (address, Redding), and Frank J. Crane was mill superintendent. According to Dowling, the company owns 14 patented mining claims

[1] See Diller, J. S., U. S. Geol. Survey, Geol. Atlas, Redding folio (no. 138). 1906.

and other patented ground in Sec. 3, 10, T. 32 N., R. 5 W., to make a total of 360 acres. The property is at the south end of the Old Diggings District (which see) and is nine miles by road north of Redding.

Cyanide mill at Walker Mine.

The rhyolitic dike that passes through the northern part of the district appears to finger out into several smaller dikes in this property, and some breccia is associated with them. The property contains six known veins. Most of the ore mined recently came from an ore-shoot 180 ft. in length on one of these. It varied from 3 ft. to 32 ft. in width, and was mined partly from a glory-hole and partly underground by the square-setting method. Stopes were driven from an intermediate level 40 ft. below the surface and from a main adit-level 110 ft. below the surface. Several hundred feet of development work were done on two other veins on the main adit-level. One of them showed 6 ft. to 8 ft. of quartz, some of which was stoped, but it was low in grade. The other was near the surface, and spiling was needed in the drift. It was to be mined later with surface-workings. These veins strike northeasterly and dip 60° northwest. In the glory-hole, a parallel vein was mined with the 3-ft. to 32-ft. vein, also the horse between the two veins, to make a total width of 54 ft. A new adit level, the Clara adit, 80 ft. lower in elevation than the main working adit, was started.

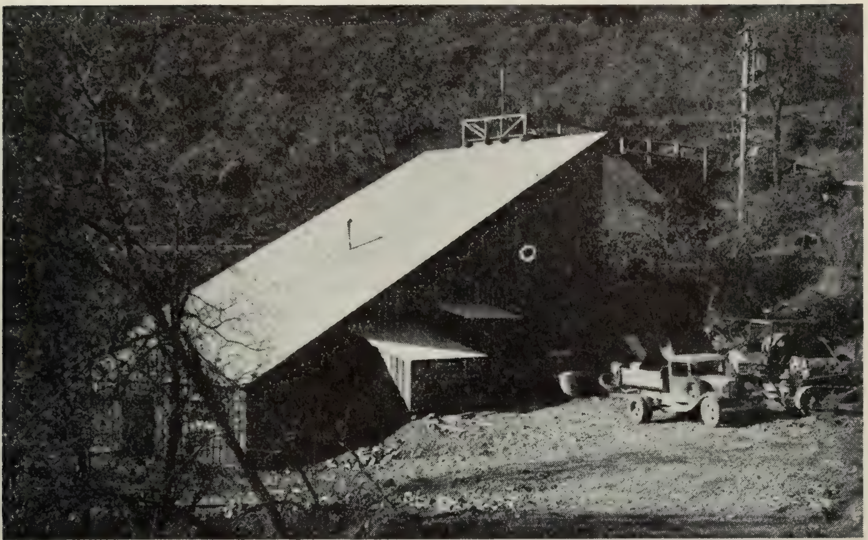
On the Josephine claim, about 2000 ft. farther south, 140 ft. of drifting was done from a new adit on a 4-ft. vein, which pinched near the face. Ore from the drift was milled but no stoping was done. Surface outcrops beyond the face of the adit were to be stripped. Mine equipment included an Ingersoll Rand two-stage compresser of a capacity of 350 cfm., Ingersoll Rand air drills and Ingersoll Rand detachable bits; also a No. 7 Caterpillar tractor with angledozer.

Gold was recovered from the ore in a new all-slime cyanide mill, which was started August 17, 1936. It contained the following: Blake crusher, bucket-elevator to fine-ore bin, automatic feeder to 6 ft. by 5 ft. Joshua Hendy ball mill in closed circuit with Dorr classifier, from which 71% to 80% of the overflow passed through a 200-mesh screen. Pulp went to Hardinge mill thickener, 8 ft. by 24 ft., then to Devereaux agitator, 17 ft. by 20 ft., then to two Devereaux agitators, 8 ft. by 8 ft., then to continuous counter-current decantation in four Hardinge thickeners, each 8 ft. by 20 ft. All tanks are of steel with welded seams. Gold was precipitated from solution by the Merrill-Crowe system using cloth bags. Precipitate was melted to bullion in a tilting furnace containing a No. 60 graphite crucible.

In 1938, this property was operated under lease by *Stewart & Brown* (A. O. Stewart and W. L. Brown), 206 Sansome Street, San Francisco. The Clara adit, started by Star Gulch Mining Co., was continued to tap the veins. At the 540-ft. point, it crosscut a large body of quartz, 20 ft. or more in width, but part of it was low in grade, and a stope was started to take out the best 4 ft. to 5 ft. of ore. This vein has a steep dip to the east. Within the next 75 ft. of cross-cutting, two other veins were cut, one vertical, the other with a steep dip to the west. The third vein was stoped to a height of 20 ft. above the level and to a width of 3 ft. Strikes of these veins vary from N. 10° E. to N. 35° E. From an old level, 100 ft. still lower in elevation, 100 ft. of crosscutting and some raising were done. The portal of this adit is near the mill and office-building.

When Stewart and Brown first took the property, surface ore was being mined, and an excess of slime was causing trouble in the mill. A hydro-separator consisting of a wood-stave tank, 20 ft. in diameter by 7 ft. deep, with mechanism similar to that in a Dorr thickener, was installed. To aid in the separation of slime, 20 lb. of Daxad, a chemical sold by Dewey-Almy Chemical Co., 4000 E. 8th Street, Oakland, and 200 lb. of tri-sodium phosphate, were used to each 100 tons of ore as deflocculators. The barren slime was discharged to waste in a special pond above the mill, where sulphuric acid was added as a flocculator. Several other small changes were made in the mill to increase the tonnage. An additional thickener, 24 ft. in diameter by 8 ft. deep, was installed, and the four thickeners formerly in series were arranged two by two in parallel. This gave three steps of countercurrent washing instead of four. Mill tonnage was increased from 40 tons to 100 tons per day. An assay office was added, but was later removed. Late in 1938, the property was allowed to revert to Star Gulch Mining Co.

Washington Gold Mining Company is controlled by Dr. Geo. Grotefend of Redding. It includes several hundred acres of patented and unpatented mining claims in Sec. 16, 17, T. 33 N., R. 7 W., covering most of the hill between the two forks of the stream above French Gulch. It was located in 1852, and is one of the oldest quartz mines in the state. It has been operated on and off ever since, and has produced a total amount of gold variously estimated at between $1,000,000 and $2,000,000.



Flotation Mill at Washington Mine.

By means of a series of five levels it has been developed from a point roughly 250 ft. above creek-level to the outcrop, 845 ft. above creek-level. The upper workings are partly in the Bragdon slates with the dikes of intruded soda-granite-porphyry and diorite-porphyry characteristic of the French Gulch district. Copley meta-andesite is found in some of the lower workings, and this may be intruded by andesitic dikes similar to it in appearance. Two main veins have been worked, one striking north and dipping flatly east, the other striking a little north of east and dipping steeply to the north. The north-south vein where opened conforms closely to the contact between andesite and slate. Small stringers in the vicinity of dikes have also yielded considerable ore. Ore is principally white quartz with considerable pyrite and a little galena, sphalerite, and arsenopyrite. A little antimony is contained, and one ounce of silver to each three or four ounces of gold.

The Washington mine is now being operated by *J. H. Scott Co. with Durand A. Hall,* Room 634, Merchants Exchange Building, San Francisco. Austin H. Merrill, French Gulch, is superintendent at the mine. The crew in the mine varies in size from 10 men to 20 men depending on the amount of development work being done. A new combination bunk house and boarding house has been built to house the crew. The mine is equipped with two portable type compressors of 320 cfm. each.

The H level, a crosscut adit, 354 ft. below the outcrop, strikes the 'East and West' vein at a distance of 500 ft. from the portal. New work was started at a point in the west drift, 500 ft. west of this intersection. The vein strikes S. 70° to 80° W. and has a nearly vertical dip. The new work is 150 ft. to 250 ft in length, and reaches a height

of 175 ft. to 200 ft. vertically above the H level. A shoot of good milling ore, 4 ft. to 11 ft. in width, has been developed for a vertical distance of 200 ft., and a parallel vein, 4 ft. wide, of ore of much higher grade has been developed to a height of 120 ft. The vein of higher grade has not been developed as extensively as the other but will probably have considerable length according to indications of present exposures. The horizontal distance between the veins is 20 ft. to 25 ft., and in places it has been possible to follow stringers across this distance and thus to make mill ore of all rock broken from the crosscut.

The old levels did not reach these shoots of ore because they did not extend far enough to the west by 150 ft. The I (eye) level must be driven 660 ft. to get under the new ore. As it is 220 ft. below the H level, a winze from the H level will be driven first.

At least two things that may be of importance to other mines of the district have been brought out by this work. Walls of the new ore shoots appear to be Copley meta-andesite, a formation that formerly has not been considered particularly favorable to the occurrence of ore shoots in the district. However, the possibility also exists that the andesite is a dike of the same appearance as the Copley meta-andesite intruded into the latter. This point needs further study. In either case, good ore shoots are possible in an andesitic formation far removed from slate. A second point is that the so-called 'walls', which were followed with great confidence by former operators, and which were supposed to limit the ore, are just as likely to be in the middle of the vein as to limit it. This is apparently caused by strike-faulting in the plane of the vein, which complicates the structure. In places the movement has been nearly horizontal. Veins also branch, and in some cases the branches that were best mineralized were not the ones that were followed with the drifts. Much ore remains behind these so-called 'walls'.

A new 35-ton mill, constructed in such a way that it can readily be enlarged, has been built on the adjoining Halcyon property, which is also controlled by J. H. Scott Company, at a distance of 0.8 mile from the Washington. One man with a 4-ton truck keeps the mill supplied with ore, and does part of the crushing. Ore is dumped on a grizzley with 1½-inch openings and oversize is crushed to 1-inch by a 7-inch by 9-inch Dodge crusher driven by a 5-hp. motor. Bins for coarse ore and fine ore hold 25 tons each. A Challenge feeder delivers ore to a 4-ft. by 8-ft. Colorado Iron Works rod mill with wave-type manganese-steel liners. This is in closed circuit with a simplex rake-classifier and a Pan American placer-type jig driven by a ½-hp. motor. This jig makes a concentrate in the ratio of 80 to 1, and all but the very finest free gold is recovered in it. The concentrate is further reduced in the ratio of 10 to 1 in a Pan American pulsator-type jig. Reject is shipped to a smelter and concentrate is treated in an amalgamation-barrel driven by a 3-hp. motor. Of the total gold in the ore, 40% to 50% is thus recovered as amalgam, which is retorted, and the resulting gold is shipped directly to the mint. Rod mill and classifier are driven by a 40-hp. electric motor.

Overflow from the classifier passes over a plate for amalgamation thence to four 28-inch Kraut flotation cells driven in tandem by two

5-hp. motors. Flotation concentrate carries roughly 40% of the gold in the ore. Totol recovery is 90% to 95%. Below the flotation is a table of the Wilfley type driven by a 1-hp. motor. Water is delivered from Scorpion Creek by 4400 ft. of ditch. A smaller supply at a higher pressure is available from the McGill tunnel of the Halcyon mine. The crew in the mill comprises three to four men and a foreman. References to published information on earlier operations at this mine are contained in the accompanying table of mines.

White Girl and Indian Girl placer claims of 20 acres each in Sec. 9, T. 31 N., R. 5 W., in the Centerville Mining District, five miles southwest of Redding, were patented to Adella Gay of Berkeley in 1937.

Willow Creek Mines, Inc.—see Greenhorn.

IRON.

In addition to the magnetite ores of the McCloud River region, which have been mentioned in earlier reports of the State Mineralogist, another important reserve of iron exists in residues from operations of The Mountain Copper Company, Ltd. At Mococo, near Martinez, are upward of 750,000 tons of tailing from the copper-leaching plant that contain approximately 52% iron. Sulphur has been removed from the original pyrite of this ore, which was mined in Shasta County, for the manufacture of sulphuric acid, and 0.5% sulphur remains in it, possibly more. At any rate, it must be re-roasted if it is to be used as a source of iron. Still larger accumulations of iron-bearing residues have resulted from the cyanide leaching of gossan at Iron Mountain, 17 miles from Redding. Much of this probably carries a high enough percentage of iron to be considered an ore of iron, but definite figures on it are lacking.

The fact that no pig iron industry now exists on the Pacific coast is usually attributed to the absence of a supply of coking coal here. Chas. G. Maier[1] of the U. S. Bureau of Mines seems inclined to dispute this statement on the basis of experiments made at Mococo in which butane (as a substitute for natural gas) was used as the reductant. The gas was converted into a mixture of carbon monoxide and hydrogen, and iron ore was reduced to sponge-iron in a rotary kiln. While some technical success was achieved, iron was made, and steel was made from the iron, the process has not yet been proved an economic success. This phase of the matter is summed up in the following quotation, which Maier states was contained in a letter to him from William F. Kett, general manager of The Mountain Copper Company, Ltd., which financed the large-scale experiments:

> "We appreciate fully that our cooperative work in this connection has produced results of great technical interest and significance and possible future commercial value. However, we can not see, for the moment, how a continuation of the expense of this experimental work is justified by any reasonable expectation of adequate financial returns to us under present-day conditions."

[1] Maier, Chas. G., Sponge-iron experiments at Mococo: U. S. Bur. Mines Bull. 396, pp. 1-81, 1936. Obtainable from Superintendent of Documents, Government Printing Office, Washington, D. C., for 15 cents per copy.

Maier sums up the iron and steel situation on the Pacific coast as follows:

> "It has been estimated that the six major steel plants of the Pacific coast have an annual ingot capacity of 600,000 tons. The present need for tin plate averages 300,000 tons yearly for California alone, of which some 12% is manufactured locally. If the consumption of other iron and steel products in 1929 may be taken as an approximate estimate of the normal requirement for such products, it may be estimated further that 65,000 to 75,000 tons each of cast-iron pipe and steel reinforcing bars and 300,000 to 400,000 tons of structural shapes and plates will be required annually in California.
>
> "During 1929 the price of Utah basic pig iron was $25 to $26 per gross ton in San Francisco; but for the same year the Iron Age composite pig iron price was $18.43, indicating a geographic differential at that time of about $7 per ton. Although the price of heavy melting scrap in eastern centers is usually about $2 less than the price of pig iron, the same thing is not true of local prices on the Pacific coast, where scrap often costs less than half as much as pig iron. The minimum cost of the materials that compose one ton of pig iron produced in eastern centers may, for the same period, be taken near $14, of which approximately two-thirds represents the cost of ore.
>
> "The citation of such figures is a necessary preamble to any consideration of the immediate practicability of reducing iron ores on the Pacific coast. Thus, it is evident that one normal size blast furnace could just about satisfy the complete pig iron requirements of the district, assuming pig-iron-scrap ratios normal to open-hearth practice. Even if the fuel requirements could be met, the erection of a blast furnace would not be commercially attractive under such conditions. Any immediate utilization of local iron resources must obviously be upon a much smaller scale than the blast furnace, and it may be necessary to produce a product capable of competing with scrap iron at about $10 per ton if a sufficiently wide market is to be reached."

The only cost-figures given on the actual experiments are the costs of building the apparatus, of which the total was $8,883. Based on the experiments, cost-figures for a plant of a capacity of 10 tons of iron per day, or more than 10 times the capacity of the kiln actually used, are given. S. B. Thomas, who actually conducted the experiments, estimates the cost per ton of iron in the 10-ton plant at $20.449. Maier revises this estimate to $14.864 per ton. In a 25-ton kiln of a modified design, which has not yet been tried, Maier thinks the cost per ton of iron could be reduced to $10.33. No cost for ore, which is at present a waste product, is included in these figures. All of the figures on the production of sponge-iron apparently refer to tons of 2000 lb., but this is not definitely stated in all cases. The steel produced from the sponge-iron contained 0.4% copper, which would be an advantage for some uses, but which would limit its market for other uses. For further details reference should be made to Maier's bulletin, which is cited above.

Electric Smelting.

Construction of the Shasta dam, which will presumably produce cheap electric power, may revive interest in electric smelting. However, a very drastic reduction in electric rates would be needed to make the production of pig iron an economic possibility. A dollar invested in coke (at $4 per ton) in eastern states will buy nearly 10 times as many heat-units as a dollar invested in electric energy at

the lowest rate now obtainable in northern California (½¢ per kwh.). Some coke or charcoal must be used even in the electric furnace to convert iron oxide into iron. With electric power at 1½ to 3 mills per kwh. and materials including iron ore, coke, limestone, dolomite, chromite, and manganese at $11.67 per ton of iron produced, Miller[1] has calculated that the cost of producing pig iron electrically in the Portland-Bonneville area would be considerably higher than the cost of competitive blast furnace iron produced at Ironton near Provo, Utah. Hence electric smelting is more likely to be attractive for ferro-alloys such as ferrochrome, ferromanganese, ferro-molybdenum, and ferrosilicon. The possibility of smelting high-grade copper concentrates electrically has been considered briefly under the general heading of 'Power' above. Such figures as are available for operations of Noble Electric Steel Company indicate that costs of both power and labor were excessive, judged by present prices of the products.

Jennings Group comprised eleven claims containing 220 acres in Sec. 7, 8, T. 35 N., R. 3 W., on the northeast side of Hirz Mountain, nine miles east of the Pacific highway from a point near Delta. A large deposit of magnetite is said to occur here. The McCloud limestone is intruded by the quartz-augite-diorite, the same large dike that is found on the property of Shasta Iron Company.

The Mountain Copper Company, Ltd., in Sec. 34, 35, T. 33 N., R. 6 W., at Iron Mountain (post-office address: Matheson), 17 miles northwest of Redding, has large reserves of iron in residues remaining from cyanide-leaching of gossan. At Mococo, near Martinez, are other large accumulations remaining from pyrite which was mined in Shasta County primarily for its content of sulphur. This is described more fully in the general section on iron above. At Iron Mountain are also undeveloped outcrops of magnetite.

Noble Electric Steel Co. held property in Sec. 21, 25, 26, 35, T. 34 N., R. 4 W., and operated an electric smelter at Heroult. The plant was built about 1907 and until 1914 produced pig iron. Charcoal, barren quartz, limestone, and iron ore from the nearby claims of the Shasta Iron Company were charged into the furnaces, and a superior quality of pig iron was made. During the war-period, ferromanganese, ferrosilicon, and probably some ferrochrome were made. The property has not been worked in recent years, and practically all of the equipment has been junked.

Shasta Iron Company owns 205 acres of patented mining claims in Sec. 26, T. 34 N., R. 4 W. Present address is 384 2nd Street, San Francisco. This property produced the ore that was smelted electrically by Noble Electric Steel Company; also considerable ore that was shipped to other steel plants on the Pacific coast. The magnetite follows the irregular contact of McCloud limestone and quartz-augite-diorite in a northeasterly direction. The ore mined during

[1] Miller, Raymond M., The feasibility of establishing an iron and steel industry in the lower Columbia River area using electric pig iron furnaces: Corps of Engineers, United States Army, Portland, Ore., 2 vols., 1936, 511 pp. and maps, cited by
Dean, R. S. and von Bernewitz, M. W., Smelting ores in the electric furnace: U. S. Bur. Mines Inf. Circ. 6955, 32 pp., 1937.

seven years is said to have contained 65% to 68% iron, 1% to 3½% silica, .02% sulphur, and .012% phosphorus. The mine was worked by two open quarries 140 feet apart in elevation. From the lower quarry it was trammed to the head of a steep gravity-tram 1600 ft. long, which delivered it to railroad cars or to the smelter at Heroult. The property has not been worked during recent years.

LEAD.

Lead has been produced in small quantity as a byproduct from copper and silver ores. A few prospects containing galena as the principal ore have been worked on and off during recent years at points near Ingot and Round Mountain.

Asher Prospect is owned by James G. Asher and others of Ingot. It is adjacent to the highway two to three miles north of Ingot. A 60-ft. prospect shaft sunk just below the highway has exposed small quantities of ore carrying galena and sphalerite. The work was done some years ago by C. A. Hill of Ingot.

Highgrade Lead Prospect in Sec. 27, T. 34 N., R. 1 W., near Round Mountain, is owned by E. Cartwright, Hamilton and Morris, Chico. In 1937-1938, Chester L. Proebstel, Redding, had a lease and option on the property, and J. W. Frederickson, Round Mountain, was living on it. Proebstel drove two adits, each about 80 ft. long, and with a difference in elevation of roughly 15 ft. to further prospect the ground. Small quantities of ore containing a high percentage of galena with some sphalerite have been found. The new adits are in the oxidized zone, and show some oxidized lead and zinc minerals. The shaft mentioned in State Mineralogist's Report XXII has been filled, and the mill has been wrecked.

Jones Property in Sec. 5, 6, T. 30 N., R. 6 W., between Igo and Ono, is owned by Leslie Jones, Thelma L. Jones and Vivian A. Jones of Igo. Some surface prospecting has been done here on outcrops showing galena and sphalerite. Gold and silver are said to be contained also.

Sugarloaf and Homestake Groups comprising five claims in all in Sec. 4, T. 33 N., R. 2 W., are held by C. A. Hill of Ingot and Chas. Walters of Montgomery Creek. From Redding the property is reached over 21 miles of the Alturas highway and 5½ miles of steep mountain road. Elevation of the claims varies from 1500 ft. to 2000 ft.

On the Sugarloaf group, a 25-ft. vertical shaft cuts several feet of siliceous ore showing plentiful pyrite, sphalerite and galena. The ore is said to contain gold and silver also. It is on a rhyolite-slate contact showing gouge, the slate forming the hanging wall and the rhyolite the footwall. The ore is probably replaced rhyolite. The strike is northeast, and the dip is 45° northwest. At a point 40 ft. below, an adit runs for some distance in the slate, then turns and cuts the contact. The total length is 250 ft. A drift of 50 ft. on the contact shows occasional bunches of ore similar to that in the shaft. At a point 120 ft. lower in elevation than the shaft, an adit crosscuts

the slate for 400 ft. then turns and follows the contact for 400 ft. Mineralization shows in the last 25 ft. to 30 ft. and the face of the adit, which is several feet under the contact in the footwall, shows 2 ft. of ore carrying pyrite, sphalerite and galena. It seems probable that by breaking over to the contact a considerably greater width of ore could be exposed. The face of this adit is practically under the portal of the one above.

On the Homestake are two 25-ft. shafts full of water. In the creek, only a few feet from one of these shafts, quartz containing sphalerite, galena and chalcopyrite is seen along five or ten feet of the bed of the creek; but it is so covered with dump material and other detritus that the strike, dip and true width can not be determined.

LIMESTONE.

Limestone probably occurs more abundantly in Shasta County than in any other area of equal size on the Pacific coast. To the west and northwest of Kennett, at a distance of two to four miles, are deposits of Devonian age, from which limestone was quarried for many years to supply flux for the Kennett smelter. Some of it was burned or calcined here also and sold for other local uses. The McCloud limestone of Carboniferous age outcrops in small lenses near Lilienthal, eight miles northeast of Redding, and extends north past the Baird Fish Hatchery, outcropping almost continuously for a distance of 30 miles, to a point in the mountains northeast of Castella. The large outcrops, 2000 ft. in width, near the fishery, are just across the McCloud River from the Pacific highway, and a striking view of these gray limestone mountains is obtained by persons traveling on the highway. The Hosselkus limestone, of Triassic age, outcrops at intervals for a distance of 15 miles, in a north and south direction, in the mountainous north-central portion of the county to the northeast of Bully Hill. From a very large outcrop at Brock Mountain, six or seven miles east of Bully Hill, some limestone has been mined for use as smelter flux. The lens of this limestone that is most accessible at the present time is cut by the state highway for a length of several miles just east of Ingot.

The Kennett limestone (Devonian) is a gray, highly fossiliferous limestone that resists erosion more effectively than the shales and thin sandstones about it, so it forms prominent ledges that may be seen for miles.[1] The old Holt and Gregg quarry, four miles from Kennett, on the road to the Golinsky mine, is in this limestone. The face of the quarry, which has been affected by caving for many years, with a sloughing of surface soil, is heavily stained by oxides of iron, and the iron content is no doubt greater than that of the solid limestone.

The McCloud limestone (Carboniferous) is dark gray and massive below and somewhat thinner bedded above, with nodules and sheets of gray chert. The largest and most accessible exposures are at Gray Rocks, 13 miles north of Redding, and farther north on the McCloud River opposite the U. S. Salmon Hatchery. It stands out as bold outcrops, which when large form prominent ridges and peaks. Conspicuous outcrops are seen on top of a ridge in Sec. 10,

[1] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Redding folio (no. 138), 1906.

T. 33 N., R. 4 W., half a mile south of the Black Diamond road. These outcrops are one mile east of the Pacific highway, but the distance to them by the Black Diamond road is two miles, and the rise in elevation from the highway to the deposit is roughly 1000 feet.

The lowest division of the Hosselkus limestone (Triassic) is about 50 feet in thickness, and consists of rather hard, pure limestone, thin bedded, dark bluish, and with abundant fossils. Next above is 100 feet of hard siliceous limestone, and finally there is an upper 50 feet of hard siliceous limestone, somewhat more massive. In general the limestone is much thinner bedded and darker than the McCloud limestone, with which it might otherwise be confused. The main mass of the Hosselkus limestone is exposed at Brock Mountain, where by a gentle fold its outcrop is widened to two miles. Along the strike the outcrop is continuous for seven miles. This limestone is well exposed in a road-cut on the Redding-Alturas highway, at a point 28 miles east of Redding. The north side of the cut is 20 to 50 feet high, and the limestone is seen at a height of fully 100 ft. above the road at a point only about 100 feet to the north. The road parallels the strike of the limestone for several miles. Some shaly layers, each a few feet wide occur in it.

Bayha Land Company (Lime Mountain Consolidated), c/o W. D. Tillotson, Redding, owns a large part of the Gray Rocks deposit in the E½ Sec. 3, T. 33 N., R. 4 W., and in Sec. 2 and 10 adjoining, a little over a mile south of Pit River. The old line of the Sacramento Valley and Eastern Railroad follows the north bank of the Pit River, and connects with the Southern Pacific about five miles to the west. However no trains have passed over the Sacramento Valley and Eastern for years, and it will be flooded by the reservoir backed up behind Shasta dam.

Briggsville (Moorestown) Limestone Quarry is on Clear Creek, six miles by road west of Girvan, in N½ Sec. 31, T. 31 N., R. 5 W. Years ago an old stone kiln using wood fuel was built here, but evidently little lime was burnt. J. H. Hill, Redding, relocated the property and in 1925 sold a few hundred tons of slacked lime for agricultural use.

A lens of limestone nearly 100 ft. thick outcrops conveniently for quarrying on the slope near the roadside. The exact size of the deposit can not be judged because it dips into the hill, and farther back is covered by overburden. All equipment has been removed from this property.

Estate of D. P. Doak, c/o Mrs. J. F. McGill, Oakville, California, owns the SE¼ of Sec. 23, T. 34 N., R. 4 W., containing a large limestone deposit, and lying one-fourth to one-half mile southeast of the U. S. fish hatchery. This is a large body, adjacent to which Shasta Iron Company operated a limestone quarry on the south end of the deposit in Sec. 26 for years.

Holt & Gregg Quarry, property of *United States Smelting, Refining and Mining Exploration Company,* c/o E. A. Hamilton, 921 Newhouse Building, Salt Lake City, Utah, in the W½ Sec. 34, T. 34 N., R. 5 W., supplied the Keswick and Kennett smelters with limestone

for years. Lime was also burned and sold for various commercial uses. With the exception of a small tonnage recently mined for use in the small smelter of Backbone Gold Mining Company, no limestone has been produced for years. The old electric tram line has been converted into a truck-road to serve the Golinsky mine, and this makes possible a four-mile truck haul from the limestone quarry to Kennett.

Moxley Deposit was assessed in 1936 to J. S. Gregory, c/o Frank Golden, Hobart Building, San Francisco, and about the same time was reported to be optioned to Shasta Cement Materials Association. It includes all of fractional Sec. 13, T. 34 N., R. 4 W., containing 622 acres. Practically all of the section except part of the southeast quarter contains limestone as mapped by the U. S. Geological Survey. A maximum elevation of 3114 feet is reached.

The lower, western part of this immense deposit is owned by Shasta Cement Materials Company. The contact of limestone on the west with quartz-augite-diorite is at about 1500 feet elevation, and about 700 feet above and one-half mile east of McCloud River, so it can be seen that by starting a quarry on the west edge of deposit, backs of 1600 feet would ultimately be had. Estimating average backs of 1000 feet for one-half the area, the immense total of over 1,000,000,000[1] tons of available limestone would be indicated. Actually the amount no doubt exceeds this.

The following is a reported analysis of limestone from the deposit:

Silica (SiO_2)	1.10%
Iron oxide (Fe_2O_3)	0.20%
Calcium oxide (CaO)	52.16%
Magnesium oxide (MgO)	2.38%
Aluminum oxide (Al_2O_3)	0.24%
Ignition loss	43.96%
	100.04%
Indicated calcium carbonate	93.20%

This analysis agrees with quoted analyses from the quarry in Sec. 26, where large tonnages have been shipped over a period of years to smelters.

The nearest sub-station from which electric power could be obtained is at Heroult, on Pit River about three miles south, where Noble Electric Steel Company formerly operated electric iron smelting furnaces. A large shale deposit covering parts of three sections lies 2½ miles west and is conveniently located for cheap operation.

Shasta Cement Materials Association, c/o D. V. Saeltzer, Redding, is recently reported to have had under control 1262 acres in Sec. 13, 14, 16, 23, 24, T. 34 N., R. 4 W., of which 942 acres are patented, and the balance held by two 160-acre mining claims. According to M. E. Dittmar, who has furnished all of the analyses shown here for the Association, the limestone is one and a half miles in length by an average of three-quarters of a mile in width. The land held in Sec. 16, 320 acres, covers a large shale deposit. Possibilities of using Shasta County coal, and gypsum from the Bully Hill mines to the east, have been considered in connection with plans for a cement plant.

The shale holdings in Sec. 16 have been estimated by M. E. Dittmar to contain about 200,000,000 tons of shale, and the following is an

[1] Logan, C. A., State Mineralogist's Report XXII, p. 194, 1926.

analysis of it reported to have been made by Smith, Emery and Company:

Silica (SiO_2)	57.51%
Iron oxide (Fe_2O_3)	8.28%
Calcium oxide (CaO)	2.98%
Magnesium oxide (MgO)	2.61%
Titanium oxide (TiO_2)	0.81%
Manganese oxide (Mn_3O_4)	1.34%
Aluminum oxide (Al_2O_3)	19.85%
Ignition loss	4.46%
Alkalies (by difference)	2.16%
	100.00%

The following limestone analyses were made for M. E. Dittmar by the Montana Assay Office, 142½ Second Street, Portland, Oregon:

	1	*2*	*3*	*4*
Silica	.41%	1.02%	.60%	.60%
Iron oxide	.49	.20	.30	.30
Alumina	.64	.61	.50	.40
Magnesia	.36	1.12		
Magnesium carbonate			.81	1.98
Calcium carbonate	97.57	96.07	98.09	95.33

All of the above were taken from limestone that was somewhat weathered.

Shasta Iron Company, 384 Second Street, San Francisco, owns a large limestone deposit adjoining their iron mine in N½ of Sec. 26, T. 34 N., R. 4 W., 1¾ miles north of the Sacramento Valley and Eastern Railroad. This is the southern part of the deposit mentioned under Doak.

This limestone property is the only one in the district that has been developed commercially. A quarry face 200 feet long by 100 feet high was opened and limestone was shipped to Bully Hill for flux while the smelter was in operation. At present it is idle. This quarry was at the same elevation as the lower iron quarry, and the stone was delivered to railroad cars at Heroult over a gravity surface tram line 1600 feet long.

The following is an analysis of the limestone, quoted by Tucker:[1]

Silica (SiO_2)	1.02%
Alumina (Al_2O_3)	0.61%
Magnesia (MgO)	1.12%
Calcium oxide (CaO)	53.80%
Iron oxide (FeO)	0.20%
Carbon dioxide (CO_2)	43.25%
	100.00%

MANGANESE.

Low-grade manganese prospects were found on the *Pit River Consolidated* claims in Sec. 1, T. 33 N., R. 4 W., and Sec. 36, T. 34 N., R. 4 W., a mile southeast of the Heroult smelter, and in the vicinity of the Peterson group of claims. In 1917, Noble Electric Steel Company leased the claims and experimented with the material in the manufacture of silico-manganese,[2] but found it unprofitable. The deposit consists of manganese oxide filling joint planes and cracks in schist, and carried 20% to 28% manganese, 23% to 37% silica, and 6.7% iron.

Manganese prospects are also reported near Pit River in the vicinity of the Exposed Treasure Barite claims in the southwestern part of T. 36 N., R. 1 W. They are undeveloped.

[1] Tucker, W. B., Calif. State Mineralogist's Report XVIII, p. 733.
[2] Logan, C. A., State Mineralogist's Report XXII, p. 199.

A manganese prospect has been noted near Beegum Creek at a point about two miles southwest of Platina, in Sec. 28(?), T. 29 N., R. 9 W. It is exposed for a width of 10 ft. in a cut which is 10 ft. by 10 ft. in plan, and is said to run 40% manganese. It looks very black and solid on natural planes of fracture, but if the more resistant chunks are broken much light-colored material is found inside, so silica is probably fairly high. About two miles of road on steep hillsides will be required to reach it.

Bibl: State Division of Mines Bull. 76, pp. 80-81.

MINERAL PAINT.

The late T. H. Peterson of Heroult exhibited samples of so-called mineral paint for a number of years. The deposit has resulted from the decomposition of iron-bearing rocks, and apparently consists largely of clay and other products of rock-decay. Various shades of yellow and red are found, but the material is not of uniform quality over distances greater than a few feet, and careful sorting would be required to give a uniform product. The writer assisted Peterson to bring this material to the attention of manufacturers of paints containing mineral pigments, but so far as is known no sales resulted. The property comprised 20 claims in Sec. 36. T. 34 N., R. 4 W., and Sec. 1, T. 33 N., R. 4 W.

MINERAL SPRINGS.

Big Bend Hot Springs are 65 miles northeast of Redding at Big Bend of Pit River, near Henderson Post Office. Hot water issues at several places for a distance of 350 yards along the south bank of the river. The warmest and largest of the springs has a temperature of 180° and a flow of about 25 gallons per minute. The water is hard, probably containing considerable calcium. The property was equipped as a small resort about 20 years ago.

Bonville Mineral Springs are located a mile south of Hazel Creek on Campbell Creek, at a point on the Pacific Highway 43 miles north of Redding. The following analysis by Techow and Davis, 620 I Street, Sacramento, was furnished by the owner, Geo. H. Bonville, Hazel Creek, Shasta County, California. Total mineral content 234.4 grains per gallon consisting of:

Silica	8.1 grains per gallon
Carbonate of Iron	.8 grains per gallon
Calcium Sulphate	11.9 grains per gallon
Calcium Carbonate	2.2 grains per gallon
Magnesium Carbonate	2.6 grains per gallon
Sodium Chloride	127.9 grains per gallon
Sodium Carbonate	73.4 grains per gallon
Volatile Matter	7.5 grains per gallon

Bumpass Hot Springs are on the south side of Lassen Peak about one mile northwest of the junction of the Tehama-Plumas and Shasta-Tehama county-lines, and about three miles from craters opened during the eruptions of 1914. The hot springs in this region are a phase of the volcanic activity. The waters are in part acid and astringent, and sulphur crystallizes around the vents. These springs are now one of the attractions of Lassen Volcanic National Park.

Castle Crag Springs (*Lower Soda Springs*) is five miles south of Dunsmuir and a mile east of Sacramento River. The water is strongly alkaline-saline and deposits some iron. The principal constituents are sodium, calcium, magnesium, and high proportions of the carbonate and chloride radicles.

Castle Rock Springs are near Sacramento River five miles west of south of Dunsmuir. The water is similar in general character to that of Castle Crag Spring but not so strongly mineralized. The water has been marketed for many years.

There are other cold carbonated springs on Soda Creek, $1\frac{1}{2}$ miles above Castle Crag Spring, and near the river three-fourths of a mile south of Castle Rock Springs.

The lava beds of eastern and northeastern Shasta County receive a great deal of surface water which later issues as springs. Most interesting of these are the waters of *Burney Creek*, issuing only a short distance above Burney Falls; *Rising River*, 10 miles east of Burney; *Great Springs*, on Hat Creek on the north slope of Lassen Peak, and *Rock Creek Springs* on the western side of Lassen Peak.

Kosk Creek Hot Springs are on the creek of the same name two miles north of Big Bend Hot Springs, and are similar to the latter, though smaller.

Supan Hot Springs are two and one-half miles due west of Bumpass Hot Springs and the waters of the two groups are similar. These springs are within the area covered by Lassen Volcanic National Park, but have been patented as mining claims on account of the sulphur deposit. They are described on a later page in more detail under the heading of sulphur.

Bibl: U. S. Geol. Survey Water-Supply Paper 338, pp. 115, 116, 117, 140, 141, 224-227, 392.

MOLYBDENITE.

Molybdenite is found on Sec. 33, T. 37 N., R. 5 W., four miles west of Gibson. The road is rough and very steep. A tract of 60 acres near the center of the section is assessed to Jennie Schlosser, Box 162, Mount Shasta. A tract of 40 acres to the west is assessed to Hugh F. Scanlon, 1805 Yale Drive, Alameda.

The molybdenite is disseminated through a white aplitic dike consisting largely of feldspar, which outcrops at intervals on both of the tracts mentioned, but most of the outcrops are on the 60-acre tract. The molybdenite occurs as a sprinkling of thin flakes, of which the larger dimensions are about a millimeter, through the dike. Country rock is peridotite, but the dike is probably associated with the intrusion of the Castle Crags granite or granodiorite 10 miles to the north.

In 1938, the 60-acre tract was being purchased by L. H. Brown and M. M. Brown of Dunsmuir, who prospected the deposit during the summer. They traced the dike by outcrops for a length along the strike of 1200 ft. A length of 700 ft. along the strike to the southwest is the part in which the molybdenite occurs. Outcrops are seen at intervals. In 1938, a 50 ft. shaft was sunk near the center of the

1200-ft. length. At the 30-ft. level are a 16-ft. drift and a 45-ft. incline to the surface. At the bottom of the 50-ft. vertical shaft is a 10-ft. drift, which exposes the dike. It strikes S. 65° W. and dips 37° SE. Considerable faulting is evident, and this may not be the true dip of the dike. In addition to the disseminated molybdenite in the dike at the 50-ft. level, a concentration of molybdenite occurs in the gouge on the hanging wall. Ore on the dump from this work is said to run 1.5% MoS_2. Numerous other assays are said to give returns of 3.5% to 3.8% MoS_2. Widths as great as 12 ft. are seen at outcrops, but the full width is not exposed in the shaft. Some of the ore on dumps from old workings contains considerable disseminated pyrite as well as molybdenite. L. H. Brown says that 100 to 150 tons of ore were shipped from the property during the war (about 1917). A flotation plant was partly built but was not operated. Development work is to be continued in 1939.

PLATINUM GROUP METALS.

Platinum, iridium and osmium have been produced in Shasta County as a byproduct of gold dredging on Clear Creek, Cottonwood Creek and Roaring River, and by individual placer miners on Beegum Creek.

The subject was covered in our Bulletin No. 85, 'Platinum and Allied Metals in California.'[1] The Beegum Creek region, and the prospects of platinum found there, were described in some detail. Later a section of Beegum Creek in the vicinity of Platina postoffice (Noble Station) was worked by small-scale methods at a profit, in the extreme southwest corner of Shasta County. Beegum Creek, a tributary of Cottonwood Creek, here marks the county line between Shasta and Tehama counties. The slate bedrock found in places along the stream formed an ideal riffle which held the platinum swept down by erosion of serpentine and ancient shore conglomerate forming the surface of the watershed. While the platinum group metals have not yet been traced in California to any deposit in place, they probably originated in serpentine and basic igneous rocks from which serpentine is derived.

A small production of the metals was made as a byproduct of gold dredging on Clear Creek. The Middle Fork of Cottonwood Creek was a more important producer and yielded much of the platinum group metals credited to the county. The principal operator here was Shasta Dredging Company. Platinum production became an important enough factor in the operations of this company to prolong the life of the field two years. Recent production has come from Roaring River, where the ratio of gold to platinum group metals varies roughly between 20 to 1 and 30 to 1. This occurrence has been described in some detail in a recent publication of this division.[2]

PYRITE.

The Mountain Copper Company, Ltd., 351 California Street, San Francisco, (mine address: Matheson, Shasta County) is equipped to

[1] Logan, C. A., Platinum and Allied Metals in California: Calif. State Division of Mines Bull. 85, pp. 38, 48-50, 1918.
[2] Averill, C. V., Gold Dredging in Shasta, Siskiyou and Trinity counties: Calif. State Mineralogist's Report XXXIV, pp. 100, 120-122, 1938.

produce several hundred tons a day of pyrite for manufacture of sulphuric acid. On account of the competitive nature of this business, the company wishes no further information published.

SAND, GRAVEL AND CRUSHED ROCK.

Diestelhorst Plant is in Sec. 25, T. 32 N., R. 5 W., on a bar of the Sacramento River on the north side, just north of Redding. Charles Diestelhorst has built a new crushing and screening plant across the river from the old one, which has been dismantled. Material is taken from the gravel-bar with a slack-line excavator. Rocks are largely andesitic and dioritic (trap).

Diestelhorst plant for sand, gravel and crushed rock.

The excavator has a bucket of 2½ cu. yd. capacity, and handles from 40 cu. yd. to 50 cu. yd. of gravel per hour. Crushing is done with a 15-inch by 36-inch jaw crusher, a 2F Telsmith crusher and a 24-inch Symons disc crusher. The product is sized by four vibrating screens. The process is a wet one throughout, and a sluice is provided with Hungarian riffles to recover gold. It is 12 inches wide by 28 ft. long. At the time of our visit (September, 1938) no gold had yet been recovered. The crew varies from 5 to 14 men. The plant uses electric power from lines of Pacific Gas and Electric Company.

Hein Brothers, Basalt Rock, Petaluma, have built a new plant on the bank of the Sacramento River just east of Redding for the production of sand, gravel and crushed rock. It is in Sec. 6 (?), T. 31 N., R. 4 W. Gravel is excavated from bars of the Sacramento River with a ½-cu. yd. diesel dragline, and is hauled in trucks to the crushing and screening plant. This contains a 15-inch by 38-inch jaw crusher and a 3-ft. Symons disc crusher. Capacity is 60 cu. yd. per hour of concrete aggregate or 100 cu. yd. per hour of road-rock. Vibrating

screens and bins for six sizes are provided. A $\frac{3}{4}$-cu. yd. shovel of the dipper-stick type is to be added immediately. The Redding plant is in charge of J. H. Hein, Red Bluff, and E. L. Turner, Box 132, Redding.

Oaks Deposit is on the Reading Grant (San Buenaventura) in what would be Sec. 25, 26, T. 31 N., R. 5 W., if the regular system of land-surveying were projected into the grant. It is on Clear Creek near Girvan. The owner is G. E. Oaks, 1341 Yuba Street, Redding. Gravel and crushed rock have been produced at different times, but no equipment is available at this time except a loading-chute. The property may be equipped soon for the production of concrete-aggregate.

SILVER.

The South Fork Mining District located two and a half miles northwest of Igo has been described in detail by Tucker.[1] The principal metal produced here has been silver, but the district has not been active recently and only a few of the more important mines are mentioned here. Those properties from which gold has been the principal metal produced are mentioned under that heading in this report.

Big Dyke Mine located four miles northwest of Igo in Sec. 17, 18, 19, 20, T. 31 N., R. 6 W., adjoins the Silver Falls-Chicago Consolidated property to the north. It is owned by W. H. Dyke, 2006 E. 29th Street, Oakland. The owner has done development work in the mine from time to time, and claims to have discovered some good ore. The mine was idle at the time the district was visited, and the workings have not been examined by the writer.

Silver Falls-Chicago Consolidated Property has been the principal producer of the South Fork District. It is four miles northwest of Igo in Sec. 17, 18, 19, 20, T. 31 N., R. 6 W. The Pillchuck, Union Cold Spring, Richmond, Madison, Chicago, Fraction No. 1, and Fraction No. 4 patented claims are held by L. Elizabeth Bass and others of Redding. The property includes a number of unpatented claims also.

The main Chicago shaft was sunk to a depth of 210 ft. on the Chicago-Madison vein, and stoped to the surface 400 ft. southwest of the shaft. Production of these workings is reported to have been approximately $1,000,000. The shaft and nearby workings have caved, but the vein can be seen in an old stope near the shaft with a width of about one foot. The silver-bearing mineral is tetrahedrite associated with small amounts of galena, pyrite, sphalerite, chalcopyrite, and a little gold. Country rock is quartz diorite intruded by both acidic and basic dikes.

In 1900, a crosscut adit was driven into the mountain from the southwest side for a distance 3000 ft., at an elevation of 1400 ft., giving a depth of 600 ft. below the outcrop of the Chicago vein. Drifts

[1] Tucker, W. B., Silver Lodes of the South Fork Mining District, Shasta County; Calif. State Mineralogist's Report XVIII, pp. 313-321, 1922, reprinted in State Mineralogist's Report XXII, pp. 201-210, 1926.

were run out from this on various veins and fractures. Tucker published a map of these workings in the references given, which is nearly up to date. Several of the faces have been advanced 100 ft. to 200 ft. since that time. At about the point where the East Drift (28) cuts the west endline of Fraction Four is a raise. At the time of our visit, the drift was filled at this point by material from the raise. L. A. Davison stated that 10 inches to 12 inches of good ore are exposed in the bottom of the drift from the raise for a distance to the east of 200 ft.

In 1938, O. C. Wright of Igo, who was living on the property, stated that he planned to finish a raise from this main adit level to the surface, and to do other development work.

Silver King Mine owned by G. B. Wood of Redding is not in the South Fork Mining District, but is located four miles west of Redding in Sec. 16 (?), T. 31 N., R. 5 W. This is an old mine that was mentioned in State Mineralogist's Report XI for 1892. It was described in some detail by Laizure[1] in 1920.

At that time development work consisted of a 325-ft. vertical shaft with four levels. No. 1 level was at 90 ft., No. 2 at 150 ft., No. 3 at 200 ft., and No. 4 at 300 ft. Level No. 1 included drifts of 80 ft., No. 2 of 320 ft., No. 3 of 160 ft., and No. 4 of 410 ft. About 1000 tons of ore of good grade had been shipped to a smelter, and 500 tons of additional ore was partly developed.

Country rock is meta-andesite, which is cut by an intrusive dike. The deposit consists of a more or less brecciated quartz vein carrying copper and silver, which follows the contact of the dike and the meta-andesite on the footwall side of the intrusive. The dike is about 65 ft. in width, and the vein averages two feet, with a maximum thickness of eight feet. The ore-body strikes north-south and dips 82° east. The pay-shoot was 150 ft. long and 14 inches wide.

The mine has been full of water during recent years. In 1933, a plant was built to treat a dump, which the operators estimated contained 2000 tons of ore worth $6 per ton. No evidence was seen that this estimate was based on systematic sampling. The installation included a crusher, rolls, and home-made jigs with a single-cylinder gasoline engine of 20 hp. for power. Apparently little production resulted.

White Star Silver Group of Mines (Crystal) in Sec. 20, T. 31 N., R. 6 W., three miles northwest of Igo, comprises the White Star, North Star, and Contact, 60 acres, held by Albert Kingsbury and Millard Hubbard of Igo. Two veins and a branch from one of them cut the grandodiorite. The ore carries native silver, tetrahedrite, sphalerite, a small amount of pyrite, chalcopyrite, and some gold associated with the pyrite.

A crosscut adit has been driven in a direction of N. 50° W. for 500 ft. cutting the three veins including the branch vein, at a depth of 90 ft. to 100 ft. below the surface. The two main veins are about 160 ft. apart. Most of the development work has been done on the first or east vein. This was cut at a distance of 200 ft. from the portal

[1] Laizure, C. McK., Shasta County, Silver King Mine: State Mineralogist's Report XVII, p. 528, 1920.

of the adit, and drifts were run 50 ft. to the northeast and 35 ft. to the southwest and the vein was stoped for about 15 ft. above the drifts. The dip is 80° southeast. The branch vein was cut by the adit 14 ft. beyond the first vein and drifts were run 60 ft. to the northeast and 100 ft. to the southwest. Width of these veins varies from a foot to three feet with a maximum of five feet. A raise and shaft to the surface have been destroyed by stoping. The main adit continues to the third vein, and a winze has been sunk on it for 60 ft. Small shipments of ore of good grade have been made to the Selby smelter.

SULPHUR.

Supan Sulphur Works includes 220 acres of land within the area of Lassen Volcanic National Park in Sec. 21, 22, T. 30 N., R. 4 E., held by Mrs. M. C. Supan, Stella Jones, and others, c/o Milton Supan or M. C. Supan, Red Bluff. By the park highway and the state highway, the distance to Red Bluff is 50 miles.

An area of roughly an acre within a stone's throw of the park highway contains numerous hot springs, steam vents and fumaroles in rather quiet ebullition. The odor of hydrogen sulphide is strong, and the surface shows incrustations of yellow sulphur. The lava rocks are decomposed and bleached white in much of this area. At a distance of a quarter of a mile to the north, up a steep ridge, is a small depression or crater, 10 ft. to 15 ft. in diameter and only a few feet deep. From crevices in the bottom of this, steam issues with a roar and shoots to a height of 20 ft. or more. Considerable pressure apparently exists beneath the surface. Yellow sulphur is seen for a distance of 25 ft. around this vent, and there is an odor of hydrogen sulphide. At a distance of an eighth of a mile northeast of the area first mentioned, on Sulphur Creek is another and larger area (several acres) of similar appearance. Fine exposures of sulphur are seen here, but no large deposit is evident. It is possible that the proper development work would expose such a deposit. The fumes and hot water would hinder such work. Sulphur from just a few inches below the surface is almost too hot to handle.

TALC.

Ganim Gold Mines Company, of which J. S. Ganim of Schilling is president, holds a group of 14 unpatented claims in Sec. 5, 8, T. 32 N., R. 6 W., 2½ miles northwest of Schilling. The distance from Redding is 13 miles, nearly all by the Redding-Weaverville highway.

The lowest adit level on the property has a length of 900 ft. and branches amount to several hundred feet additional. At a distance of 600 ft. from the portal, a body of talc with a maximum width of about 60 ft. occurs between two bodies of siliceous material carrying sulphides. Most of the sulphide is pyrite, but there is some chalcopyrite, sphalerite, possibly a little galena, and a little gold. The strike is northwest and southeast and the dip is 45° to the northeast. Four raises in the talc average 50 ft. each. One raise, 140 ft. in length reaches the surface. Cuts here and there on the surface along the strike of the talc indicate that it has a possible length of 1000 ft. or more. Several shipments of the talc have been made. One of these of

12 to 15 carloads brought $10 to $10.50 per ton f.o.b. San Francisco. Freight and hauling cost $4.50 per ton. The following analyses are quoted from Logan.[1]

SiO_2	60.75	61.90
Fe_2O_3	0.88	0.65
Al_2O_3	2.28	0.87
MgO	30.40	30.34
Ignition loss	5.73	----
Moisture	----	0.26
Combined water	----	4.90
Alkalies by difference	----	0.90
Mn_3O_4	----	0.18

ZINC.

Zinc sulphide is associated with the copper ores of Shasta County, and electrolytic zinc was produced during the war (about 1917) both at the Mammoth plant at Kennett and at Winthrop (Bully Hill). Much zinc has been lost in the past because the copper smelters were not equipped to save it. The flue dust saved in later years at the Kennett smelter, which still remains there unworked, contains zinc as well as other metals. Zinc also occurs associated with lead at prospects near Ingot and Round Mountain. These are listed herein under the heading of lead.

Afterthought Mine in Sec. 10, 11, T. 33 N., R. 2 W., at Ingot, is assessed to Afterthought Zinc Mining Company, Ingot. It is 25 miles from Redding on the Redding-Alturas highway. A reverberatory furnace and 300-ton flotation plant were built here in 1918, but were used for only a short time. In 1925, an aerial cable-tram was built to transport ore from this mine to Bully Hill. It was 8½ miles long and had a capacity of 288 tons per 24 hours. The mine is now idle, and practically all machinery has been removed. The difficulty with the treatment of the ore by flotation appears to be that the zinc and copper minerals are so closely associated that grinding up to the economic limit of fineness is not sufficient to separate them.

Bully Hill Mine in Sec. 15, 16, 21, T. 34 N., R. 3 W., at Winthrop, is assessed to California Zinc Company, c/o E. L. Ralston, Box 538, Redding. During the war this property as well as others in the county was worked with the idea of getting out the most copper in the shortest possible time and the Rising Star Mine is credited with a production of 27,000 tons of 6% copper ore in 1918. The zinc orebodies are shells left from past operations, in large part. They vary in size from a few inches wide up to lenses as much as 30 ft. wide and 100 ft. long. The principal ore minerals contained are pyrite, chalcopyrite, sphalerite, and small quantities of galena, chalcocite and bornite, with some gold and silver. Barite and quartz are the principal gangue minerals. Operations have been centered largely around the Rising Star shaft, 1100 ft. deep, with levels 100 ft. apart. Small bodies of ore have been found within a body of gypsum, 200 ft. wide and 700 ft. long, which extends down from the 700-ft. level.

A plant for the production of electrolytic zinc by electrolysis of zinc sulphate was operated at Winthrop by General Electric Company

[1] Logan, C. A., Shasta County: Calif. State Mineralogist's Report XXII, p. 211, 1926.

Zinc oxide plant at Bully Hill.

in 1915, and made some production. In 1917, Bully Hill Mining Company took the property and in addition to shipping selected copper ore built a 150-ton flotation plant. In 1920, Daniel C. Jackling and others organized Shasta Zinc and Copper Company and began operations. The new company constructed a reverberatory furnace and a zinc oxide plant, which was put in operation in June, 1922. It was shut down in December, 1922. Late in 1924, California Zinc Company took the property, and for a time treated about 200 tons of ore per day to produce a bulk-concentrate containing zinc, copper, lead, gold and silver. This was shipped to Belgium for further treatment.

The property has not been operated during recent years, but the zinc oxide plant is kept in repair, and the company maintains an office at the plant. A little development work was done from an adit level with portal at Copper City in 1931.

Mammoth Mine in Sec. 2, 3, T. 33 N., R. 5 W., and Sec. 32, 33, T. 34 N., R. 5 W., near Kennett, is assessed to United States Smelting, Refining and Mining Company, c/o E. A. Hamilton, 921 Newhouse Building, Salt Lake City, Utah. Some zinc has been produced here in an electrolytic plant, and considerable zinc is contained in the pile of approximately 20,000 tons of flue dust that remains on the property. The flue dust contains also copper, zinc, gold, silver, lead, antimony, cadmium and sulphur. Numerous tests have been made in an effort to find a method of extracting the metals at a profit, but practically no production has been made from the flue dust. The 2200-ton copper smelter formerly operated here has been junked.

Late in 1937, a new camp was built and development work was started in the Mammoth mine. The four miles of very steep mountain road from Kennett were put in condition for travel by auto in dry weather. The main haulage level (470) was equipped with rails and

(Continued on page 191)

TABLE OF MINES AND PROSPECTS, SHASTA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST

Name	Kind of mine[1]	Location Sec.	Location Twp.	Location Range	Remarks[2] (Location or ownership)	References to reports of State Mineralogist[3]
Accident						See Sybil
A. C. Mining Co.	P	2	32 N.	5 W.	7 mi. N. Redding, Janie Williamson[4], Buckeye Route, Redding	XXXIV, p. 114
Advance Cons.	Q	2	35 N.	6 W.	7 mi. W. Delta, Regis E. Halter,[4] 2346 Placer, Redding	XIV, pp. 777-778
Afterthought	Ba	2	34 N.	4 W.	20 mi. N. Redding, Geo. Dean & Eli Popejoy, Redding	See text this report.
Afterthought	Cu, Zn	10, 11	33 N.	2 W.	At Ingot, Afterthought Zinc Mining Co., Ingot[4]	XI, pp. 31, 32; XII, p. 377; XIV, pp. 760-61; XVII, p. 516; XVIII, pp. 596-98; XX, pp. 425-26; Bull. 50, pp. 102-05; XXII, pp. 143-44, 211-13. See text this report
Akers	Cu	6, 7	33 N.	5 W.	5 mi. W. Kennett	XVII, p. 516; XX, p. 426; XXII, p. 145
Alata Lime & Brick Co.	Cl				Block 29, Redding Grant, 1¼ mi. S. Redding	XIV, p. 756
Alice (Alice Cons.)	Q	19	32 N.	5 W.	1 mi. SW. Keswick	XII, p. 245; XIII, p. 349; XIV, p. 778; XVII, p. 519
Alice	Q				6 mi. NW. Ono	XII, p. 245; XIII, p. 349
Alliance	Q				5 mi. W. Redding	XIII, p. 349
Alvina	Q				4 mi. N. Horsetown	XIII, p. 349
Al Toland	Q	26	36 N.	6 W.	7½ mi. W. Delta	XIV, p. 778
American	Q	12, 13	33 N.	7 W.	3½ mi. NE. French Gulch	VIII, pp. 564-65; X, p. 637; XII, p. 245; XIII, pp. 349, 357; XIV, p. 778; XIX, p. 135; XX, p. 15; XXII, p. 169; U.S.G.S. Bull. 540, pp. 35, 60-61. See text this report. XXIX, pp. 5-6
American Gold Dredging Co.	P				At Redding	XXII, pp. 189-90
American Zinc, Lead & Smelting Co.						XIX, p. 57
Anaconda	A	6	37 N.	4 W.	4 mi. N. Sims	XIV, p. 755; XXII, p. 128
Anavina						See Peerless
Annie	Q				2 mi. from Shasta	XIII, p. 349
Arbuckle						See Bell Cow
Arndt-Haschke	Q	33, 34	34 N.	2 W.	Near Ingot	XVII, p. 519
Arps	Cu	20, 21, 28	34 N.	3 W.	1¼ mi. N. Copper City, D. V. Saeltzer,[4] Antone Jaegel and others, 2,100 West St., Redding	XIV, p. 761; XIX, pp. 89, 90; XX, p. 427; Bull. 50, p. 110; XXII, p. 145; XXIX, p. 7
Asher (Jacksonian)	Pb				2 to 3 mi. NE. Ingot	XXII, p. 192
Atascadero Copper Co.						See Greenhorn
Atlantic	Q	17, 20	31 N.	6 W.	3 mi. NW. Igo	XIV, p. 779
Austin	B	29	34 N.	3 W.	Near Copper City	XXII, p. 129
Australia	Q	19, 30	32 N.	6 W.	3 mi. N. Shasta (?)	XIII, p. 362; XIV, p. 779
Backbone	Cu	33	34 N.	5 W.	4 mi. NW. Kennett, Backbone Gold Mining Co., Kennett[4]	See text this report
Baker	P	34	32 N.	6 W.	4 mi. SW. Shasta, M. D. Baker, Redding	XXXIV, p. 114
Baker	Q	22	34 N.	6 W.	9 mi. NE. French Gulch	XXIX, p. 7

Footnotes are at end of table.

Balaklala	Cu	10, 11, 12, 13, 14, 17, 20, 21	33 N.	6 W.	3 mi. NW. Coram, First National Copper Co.,[4] 830 Mandana Blvd., Oakland	Bull. 50, pp. 88-94; X, p. 633; XII, p. 245; XIII, pp. 61, 349; XIV, pp. 761-62; XVII, p. 516; XX, pp. 427-28; XXII, pp. 145-46; XXIX, pp. 7-8. See under "Gold" in text this report
Bald Eagle	Cu	10	34 N.	3 W.		XIV, p. 762
Ballou (Falls)	Q	7, 18	31 N.	6 W.	6 mi. NW. Igo, May V. Ballou, Anderson[4]	XII, p. 248; XIV, pp. 788-89; XXII, pp. 206-07; XXIX, pp. 8-9. See text this report
Banghart						See Mad Mule
Barite No. 1 & 2	Ba				Near Platina	XXII, p. 129. See text this report
Barnes	Co	32	34 N.	1 W.	7 mi. NE. Ingot, Oscar R. Barnes, Ingot[4]	VII, p. 191; XXII, p. 134. See text this report
Bayha Land Co.	Ls	2, 3	33 N.	4 W.	1 mi. S. Pit River near Baird, Bayha Land Co., Redding[4]	XXII, p. 194. See text this report
Baxter-Winthrop	Cu	21, 28	34 N.	3 W.	1 mi. N. Copper City	XX, p. 428; Bull. 50, p. 107; XXII, p. 146
Beaver						See Woodfill
Beegum	Co	29, 30	29 N.	9 W.	4½ mi. from Platina	XVII, p. 515; XXII, p. 137
Bell	Q				7 mi. W. Ono	XII, p. 245
Bell Cow	Q	35	30 N.	9 W.	38 mi. SW. Redding	XVIII, pp. 296, 493-94; XXII, pp. 169-70; XXIX, p. 10
Benson	Q	12, 14	32 N.	6 W.	3 mi. N. Shasta	XXIX, pp. 10-11
Betty May	Q	8	32 N.	6 W.	1 mi. NW. Schilling	XXIX, p. 11
Bidwell	Ba	2	34 N.	1 W.	Near Montgomery Creek	See text this report
Big Bend Hot Springs	MS				65 mi. NE. Redding	XI, p. 29; XIV, p. 808; XXII, p. 199. See text this report
Big Chief & Little Chief	P				Near Horsetown	XXII, pp. 187-88
Big Dyke	Ag	17, 18, 19, 20	31 N.	6 W.	4 mi. NW. Igo, W. H. Dyke, 2006 E. 29th St., Oakland[4]	XVII, pp. 526-27; XXII, pp. 204-05. See text this report
Big Four	Q				4 mi. SW. Shasta	XIII, p. 350
Billy McCormick	Q				13 mi. NW. Ono	XIII, p. 350
Bjork	Q	6	33 N.	6 W.	J. W. Thews & James Conners, Redding	See text this report
Black Bear	Q	9	29 N.	10 W.	1 mi. S. Knob	XIII, pp. 350, 359; XIV, p. 779
Black Bear	Q	11	31 N.	6 W.	At Mule Mountain	XXIX, p. 11
Black and Brown Bear	Q	6	33 N.	6 W.	6½ mi. NW. Kennett (?), C. O. Benson, 242 N. Western Ave., Los Angeles[4]	XIII, p. 350
Black Cloud & Red Cloud	Q	15	32 N.	5 W.	4½ mi. N. Redding	XVII, p. 520
Black Diamond	Q	5	31 N.	5 W.	4 mi. W. Redding	XVIII, p. 296. See text this report
Black Diamond	Cu	2, 3	33 N.	4 W.	In Stillwater District	XX, p. 428; Bull. 50, p. 108; XXII, p. 146
Blackfoot	Q				4 mi. S. Shasta	XII, pp. 245-46; XIII, p. 350
Black Hawk	Q	14	31 N.	6 W.	1 mi. NW. Centerville	XIV, p. 779
Black Prince						See Diamond
Black Spider (Jones)	Q	19	32 N.	5 W.	1½ mi. SW. Keswick, Rosa Jones, Box 487, Redding[4]	XII, p. 246; XIII, p. 350; XIV, p. 779; XXIX, p. 32
Black Tom						See Niagara
Blue Bird	Q	31	33 N.	5 W.	Wm. Owens & Richard Woehr, Redding	See text this report
Blue Danube	Q	12	32 N.	6 W.	L. Elizabeth Bass and others, Redding[4]	XXIX, p. 11
Blue Gravel	P, Q				At Redding; Owner, City of Redding	XXIX, p. 59-60. See text this report
Bodie	Q	6 32	32 N. 33 N.	7 W. 7 W.	3 mi. SW. French Gulch	XIV, 779-80
Bonanza	Q	6	32 N.	6 W.	4 mi. NW. Stella	XII, p. 256; XIII, p. 364; XIV, p. 780; XIX, p. 11
Bonville	MS				43 mi. N. Redding	See text this report
Boswell	Q	7	31 N.	5 W.	7 mi. W. Redding	XXIX, p. 11. See text this report. See "Richstrike" also

Footnotes are at end of table.

TABLE OF MINES AND PROSPECTS, SHASTA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST

Name	Kind of mine[1]	Location			Remarks[2] (Location or ownership)	References to reports of State Mineralogist[3]
		Sec.	Twp.	Range		
Bowery Bell	Q				2½ mi. NE. Shasta, Regis H. Halter, 2346 Placer St., Redding[4]	XIII, pp. 350-51
Brackett						See Minneshasta
Briggsville (Moorestown)	Ls	31	31 N.	5 W.	6 mi. W. Girvan	XXII, p. 197. See text this report
Bright Star (Iron Mask)	Q	31	33 N.	6 W.	4½ mi. NW. Stella	XII, p. 250; XIII, p. 359; XIV, p. 780; U.S.G.S. Bull. 540, p. 55
Broken Hills	Q	23	31 N.	6 W.	12 mi. W. Redding	XXIX, p. 12
Brunswick						See Miners' Group of Mines
Brushy Canyon	Cu	34	34 N.	3 W.	2 mi. S. Copper City	Bull. 50, p. 102; XIV, p. 763; XX, p. 429; XXII, p. 146
Buena Vista	Q	5	31 N.	5 W.	5 mi. W. Redding, H. G. Graves, Redding	XXIX, p. 15. See text this report
Bullard & Vanderver	Q				12 mi. NW. Redding	XII, pp. 259-60; XIII, pp. 351, 368
Bully Hill & Rising Star	Cu, Zn	15, 16, 21	34 N.	3 W.	California Zinc Co.,[4] c/o E. L. Ralston, Box 538, Redding	X, p. 638; XI, p. 33; XII, p. 377; XIII, pp. 61-62; XIV, pp. 763-64; XVII, p. 516; XX, pp. 429-32; XXII, pp. 148, 213-15; Bull. 50, pp. 106-07; U.S.G.S. Redding Folio. See text this report
Bulwer and Virginia	Q	18	33 N.	7 W.	5 mi. NW. French Gulch	XIV, p. 780
Bumpass Hot Springs	MS				At Lassen Peak	XXII, p. 199. See text this report
Bunker Hill	Q	29	32 N.	5 W.	3 mi. E. Shasta	XIV, p. 781
California and Oregon	Q				3 mi. SW. Kennett	XIII, p. 351
California Con.	Fe	26	34 N.	4 W.	Shasta Iron Co.,[4] 384 2d St., San Francisco	XXII, p. 190
California Progressive						See Clipper and Snyder
California Sandstone & Constr. Co.	SS	29	31 N.	5 W.		XIII, p. 637; XIV, p. 808
Calumet Cons.	Q	10	32 N.	5 W.	Henry D. McIntosh,[4] 3332 9th Ave., Sacramento	VIII, p. 563; X, pp. 631-32; XI, pp. 43, 395; XIV, p. 781; XXIX, p. 17. See Old Diggings also
Cambria Copper Co.						See Minnesota
Canyon Creek	Cu	4	36 N.	1 W.	E. Baker, 239 Edelen Ave., Los Gatos	See text this report
Carlson & Sandburg	P	23, 31 23	31 N. 32 N.	5 W. 5 W.	Near Redding	XXXIV, p. 114
Carnegie	Q	1	33 N.	6 W.	7½ mi. W. Kennett	X, pp. 640-41; XI, p. 399; XII, p. 246; XIII, p. 351; XIV, p. 781
Cartwright	Pb				Near Round Mountain	XXII, p. 193
Cascade Dredge	P	7	29 N.	5 W.	10 mi. W. Cottonwood	XXXIV, pp. 114-15
Castle Crag Spring (Lower Soda)	MS				5 mi. S. Dunsmuir	XXII, p. 199. See text this report
Castle Rock Springs	MS				5 mi. SW. Dunsmuir	XIV, p. 808; XXII, p. 199
Cates	Q	4	35 N.	6 W.	J. M. Cates, Bayles	See text this report
Celestine						See Double Header
Central	Q	3, 4	32 N.	5 W.	In Old Diggings District	VIII, pp. 565-66; X, p. 631; XII, p. 246; XIII, p. 351; XIV, pp. 781-82; XVIII, p. 494; XXII, pp. 170-71; XXIX, pp. 17, 18. See Old Diggings also
Chance	Cu	21	34 N.	3 W.	1 mi. N. Copper City	XIV, p. 764
Chapman & Voluntine	Q	25	31 N.	6 W.	¾ mi. S. Centerville	XIV, p. 782

Footnotes are at end of table.

Chicago Con.						See Silver Falls
Clara	Q	17	32 N.	5 W.	½ mi. W. Keswick	XIV, p. 782
Clear Creek, Placer Co.	P	34	32 N.	6 W.	4 mi. SW. Shasta	XXIX, p. 60
Cleveland	Q	15	32 N.	5 W.	4 mi. W. Redding (?)	XIV, p. 782
Cleveland	Q	9, 16	31 N.	8 W.	On Bully Choop Mountain, C. F. Foster Co., Corning[4]	XII, p. 310; XIII, p. 442; XIV, p. 887; XXIX, pp. 18, 19
Climax	Q, Ag	16, 21	31 N.	6 W.	3 mi. NW. Igo, W. W. Robinson, 5923 Ayala Ave., Oakland	XIV, p. 782; XXII, pp. 205-06
Clipper & Snyder	Q	36	34 N.	6 W.	5 mi. W. Kennett, California Progressive Min. Co., c/o Carr & Kennedy, Redding[4]	X, pp. 640-41; XI, p. 399; XII, p. 246; XIII, p. 351; XIV, p. 781; XXIX, pp. 19-20. See Carnegie also
Clover Creek	Cu	32	33 N.	1 W.	15 mi. E. Palo Cedro (?)	XVII, pp. 516-17
Clover Creek	Co	4	32 N.	1 W.		XXII, pp. 134-35
Colma	Cu	{ 6 31	33 N. 34 N.	5 W. 5 W. }	6 mi. W. Kennett	XX, p. 432; XXII, p. 148
Colorado	Q	16, 17	33 N.	7 W.	3 mi. NW. French Gulch, Robert Emmett McDonald, 760 Edgewood Road, San Mateo[4]	XIV, p. 782
Colorado	Q				2 mi. SW. Shasta	XII, pp. 246, 256; XIII, p. 352
Compton	Q	20	32 N.	5 W.	1¼ mi. S. Keswick	XIV, p. 782
Congress	Cu	4	33 N.	2 W.	2 mi. W. Ingot	Bull. 50, p. 111; XIV, p. 764
Cons. Gold Dredging Co.	P	20, 28	32 N.	5 W.	2 mi. NW. Redding	XIV, p. 783
Cons. Kascinaska (Quartz Hill)	Q	10	32 N.	5 W.	4 mi. NW. Redding, Francis Gordon and others,[4] c/o Leon C. Nyka, 2756 N. Kimball Ave., Chicago, Ill.	VIII, p. 570; XII, p. 254; XIII, p. 352; XIV, p. 783; XVIII, p. 354
Continental	Ag	7, 18	31 N.	6 W.	6 mi. NW. Igo	XXII, p. 206
Cook	Co	18, 19	33 N.	1 W.		XXII, p. 135
Copley	Q	32	33 N.	5 W.	Near town of Copley	XIII, p. 352; XIV, p. 783
Corrine	Q	32	32 N.	5 W.	1 mi. W. Redding (?)	XIV, p. 783
Cortez	Q	10	33 N.	2 W.	½ mi. NW. Ingot	XII, p. 70; XIII, p. 352; XIV, p. 783
Crown Deep						See Gold Leaf
Crown Point	Q				6 mi. W. Delta	XIII, p. 353
Crown Point & Midnight	Q	13, 24	31 N.	6 W.	10 mi. SW. Redding	XIII, p. 353; XXIX, p. 20
Crystal	Cu	11	33 N.	6 W.	Crystal Copper Min. Co.,[4] c/o C. C. Hartman, Kennett	Bull. 50, p. 113; XIV, p. 764; See Mammoth also
Crystal	Ag					See White Star
Daisy	Q				5 mi. N. French Gulch	XIII, p. 353
Dakin	Co	12	33 N.	2 W.		VII, p. 191; XIII, p. 61; XVII, p. 316; XXII, p. 135
Davis	Cr	13, 24	37 N.	5 W.	2 mi. W. Sims	Bull. 76, p. 181
Deakin & Taylor						See Old Spanish
De Dallis	Cu	34	34 N.	3 W.	1½ mi. SE. Copper City	Bull. 50, p. 102; XIV, pp. 764-65
Delta Cons.	Q	6	35 N.	5 W.	6½ mi. W. Delta	XIII, p. 353; XIV, p. 784
Desmond	Q	(?) 4	32 N.	6 W.	Mrs. Charlotte J. Desmond, 1654 Court St., Redding	See text this report
Diamond (Black Prince)	Q	18	31 N.	6 W.	4 mi. NW. Igo	XII, pp. 377-78; XIII, pp. 350, 355, 610; XIV, p. 784
Diestelhorst	R	25	32 N.	5 W.	Charles Diestelhorst, Redding	XXII, p. 201. See text this report
Diestelhorst Dredge	P				3 mi. W. Redding	XIII, pp. 354-55
Diving Bell	P	26	32 N.	5 W.	At Redding	XXIX, pp. 60-61
Doak, D. P., Estate	Ls	23	34 N.	4 W.	½ mi. SE. U. S. Fish Hatchery, D. P. Doak, c/o Mrs. J. F. McGill, Oakville[4]	XXII, p. 194
Doebleins	P				2 mi. E. Igo	XII, p. 247; XIII, p. 355

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TABLE OF MINES AND PROSPECTS, SHASTA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST

Name	Kind of mine[1]	Location Sec.	Location Twp.	Location Range	Remarks[2] (Location or ownership)	References to reports of State Mineralogist[3]
Dolcoath	Q				2 mi. E. Shasta	XII, p. 247; XIII, p. 355
Don Carlos	Q					XI, p. 398
Donkey	Cu, Zn	11	33 N.	2 W.	2 mi. NE. Ingot	XIV, pp. 765, 809; XX, p. 432; XXII, p. 148; Bull. 50, pp. 105-06
Double Header	Q	33	33 N.	7 W.	2 mi. W. Tower House, Wm. P. Donnelly & Chas. Garrett, Anderson[4]	VIII, pp. 567-68; XVIII, pp. 138, 256, 354, 405; XIX, p. 11; XXIX, p. 21
Dowling						See Walker
Dozier	Cu	13	33 N.	5 W.	4 mi. from Kennett, Dozier & Sandholt, 1313 Placer St., Redding	XVII, pp. 517-18
Dreadnaught	Q				3 mi. NW. Shasta	XII, p. 247; XIII, p. 355
Eastern Star	Q				14 mi. SW. Redding	XII, p. 247; XIII, p. 355
East View (Winnie)	Q	6	32 N.	6 W.	12 mi. W. Redding	XXIX, pp. 21-22
Edna B.	Q	6	31 N.	5 W.	1½ mi. E. Shasta (?)	XII, p. 247; XIII, p. 355; XIV, p. 785
Eiller	Q	11	32 N.	6 W.	4 mi. N. Shasta	XXIX, p. 22. See text this report
El Dorado	Q	3	32 N.	7 W.	¼ mi. SW. Tower House, J. G. Connor, Anderson[4]	XII, p. 247; XIII, pp. 355-56; XIV, p. 785; XVIII, pp. 405-06; XIX, p. 11; XXII, p. 171; U.S.G.S. Bull. 540, pp. 56-57
Ellis	Q	6	33 N.	5 W.	6 mi. W. Kennett, L. C. Monahan, M. E. Dittmar, Redding[4]	XXIX, p. 22. See American Zinc, Lead and Smelting Co. also
Emigrant						See Truscott
Empire	Q	9	30 N.	7 W.	3 mi. SW. Ono	XIII, p. 356; XIV, p. 785
Empire	Q	18	33 N.	7 W.	5 mi. NW. French Gulch, H. J. & Wm. Franck, French Gulch[4]	XIII, p. 356; XIV, p. 785
Enright						See Old Spanish
Esperanza	Q	29	29 N.	10 W.	1½ mi. E. Knob (?)	XIV, p. 785
Ethel	Q				14 mi. SW. Redding	XII, p. 248
Eureka					Pittsburg Mining District	XVIII, p. 354
Eureka Tellurium	Q	32	32 N.	5 W.	3 mi. W. Redding	VIII, p. 571; XI, p. 43; XII, p. 248; XIII, p. 356-57; XIV, p. 786
Evening Star (Bright Star, Iron Mask)	Q	30, 31	33 N.	6 W.	3 mi. N. Oak Bottom	XII, p. 250; XIII, p. 359; XIV, p. 780; XXIX, p. 23; U.S.G.S. Bull. 540, p. 55
Evening Star	Q				Near French Gulch	XVII, p. 520; XXIX, p. 22
Evening Star	Q	3, 4	32 N.	5 W.	10 mi. N. Redding	XIV, p. 786; XVII, p. 520; XXIX, pp. 22-23. See Old Diggings also
Exposed Treasure	B	33	36 N.	1 W.	12 mi. N. Montgomery Creek	XXII, p. 129
First National Copper Co.						See Balaklala
Fisk, Jim						See under "J"
Florence	Q	18	30 N.	7 W.	8 mi. SW. Ono	XIV, p. 786
Florida	Q	7, 18	31 N.	5 W.	7 mi. W. Redding	XII, p. 248; XVII, p. 520; XVIII, p. 494
Forest Queen	Cr	22	37 N.	5 W.	4 mi. NW. Gibson, Antone Orsini, Redding	Bull. 76, pp. 181-82. See Union Forest Queen in text this report

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Franklin						See Milkmaid
Franklin	Q	10	33 N.	2 W.	1 mi. SW. Ingot	XIV, p. 786
Franklin	Q	29	32 N.	5 W.	1½ mi. S. Keswick	No published report
French Gulch						See American
French Gulch District						XIV, p. 773; XXII, pp. 167-68; U.S.G.S. Bull. 540, pp. 22-79
Friday-Lowden	Cu	5, 6	33 N.	5 W.		Bull. 50, pp. 94, 95; XIV, p. 765. See Mammoth also
Gage & Martin	Q				1½ mi. S. Shasta	XIII, p. 357
Gambrinus	Q	16	32 N.	6 W.	At Schilling	XIV, p. 786; XXIX, p. 26; U.S.G.S. Bull. 540, pp. 38, 39, 50, 51
Ganim	Q, Talc	5, 8	32 N.	6 W.	2½ mi. NW. Schilling	VIII, pp. 730-31; XIX, p. 11; XX, p. 15; XXII, pp. 171-72, 210-11; XXIX, pp. 26-27. See text this report, under talc
Gardella						XXIX, p. 61. See Gleason Estate
Garfield (Lone Cedar)	Q	34	33 N.	5 W.		XI, p. 397; XIV, p. 787; XXIX, p. 34
Gas Point Dredge	P	3	29 N.	6 W.	15 mi. W. Cottonwood	XXIX, pp. 61-62; XXXIV, p. 122
Gem Cons.	Q		31 N.	5 W.	4 mi. NW. Redding	X, p. 632
General Kieselguhr Corp.	D	25, 26, etc.	37 N.	3 E.	Near Burney Falls	XXII, pp. 163-66. See text this report
Giant Cons.	Cu	19 24	33 N. 33 N.	5 W. 6 W.	3 mi. NW. Copley	Bull. 50, p. 85; XIV, p. 765
Gibson, Molly						See under "M"
Gladiator (Hiatt)	Q	15	32 N.	5 W.	5 mi. N. Redding, Gladiator Gold Min. Co.,[4] c/o W. P. Henry, Rm. 2012, Hunter Dulin Bldg., San Francisco	XXIX, pp. 27-28
Gladstone	Q	1, 7, 8 12, 18	33 N. 33 N.	6 W. 7 W.	Hazel Gold Min. Co.,[4] c/o J. F. Peatie, 79 New Montgomery St., San Francisco	VIII, pp. 568-69; X, p. 637; XI, p. 45; XII, pp. 248-49; XIII, p. 357; XIV, pp. 787-88; XVIII, pp. 43, 96, 256; XIX, p. 11; XXII, pp. 172-73; XXIX, p. 28; U.S.G.S. Bull. 540, pp. 35, 37, 46, 57-60. See text this report
Gladys	Q	34	32 N.	6 W.	10 mi. W. Redding	XVII, p. 521
Gleason Estate	P	36	31 N.	6 W.	At Horsetown	XXII, p. 188
Glidden	B	18, 19	38 N.	3 W.	7 mi. E. Castella, The Glidden Co., c/o E. L. Ralston, Box 538, Redding[4]	XXII, p. 130; XXVII, pp. 26-27. See Bully Hill also. See text this report under both barite and zinc
Gold Acres Dredge	P	2, 3	29 N.	6 W.	14 mi. W. Cottonwood, Gold Acres Dredging Co.,[4] Box D, Cottonwood	XXXIV, pp. 115-16. See text this report
Gold Bar	Q				4 mi. NE. French Gulch	XIII, p. 358
Gold Bar	P				At Horsetown	XXII, p. 188
Gold Bar No. 1-4	Q	22, 26	33 N.	5 W.	10 mi. N. Redding	XIX, p. 93; XXII, p. 173
Gold Belt	Cu	4	33 N.	2 W.	2 mi. W. Ingot	Bull. 50, p. 111; XIV, p. 765
Golden Chariot	Q	7	31 N.	5 W.	8 mi. W. Redding	See text this report
Golden Crown	Q	19	31 N.	6 W.	2 mi. NW. Igo	XIV, p. 788
Golden Queen	Q				5 mi. NW. Redding	XVIII, p. 354
Gold Hill						See Eiller
Gold Leaf (Crown Deep)	Q	5	31 N.	5 W.	4 mi. SW. Redding	XIII, p. 358; XVII, pp. 521-22; XVIII, pp. 296, 298, 354, 406, 495; XIX, p. 11; XXIX, p. 28
Golinsky	Cu	28	34 N.	5 W.	4 mi. NW. Kennett, Golinsky Copper Co., c/o W. D. Tillotson, Box 68, Redding[4]	XIV, p. 766; XX, p. 432; XXII, p. 149; Bull. 50, p. 100; XXIX, p. 29. See Backbone Gold Min. Co. in text this report
Gossan	Q				3 mi. W. Delta	XIII, p. 358
Grand View						See Black Diamond

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TABLE OF MINES AND PROSPECTS, SHASTA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST

Name	Kind of mine[1]	Location: Sec.	Location: Twp.	Location: Range	Remarks[2] (Location or ownership)	References to reports of State Mineralogist[3]
Gray Eagle	Q	10	29 N.	10 W.	1 mi. S. Knob	XIV, p. 789
Gray Eagle						See Sunny Hill
Great Falls & Hope						See Ballou
Great Verde	Cu	11, 12	33 N.	6 W.	7½ mi. W. Kennett	Bull. 50, p. 98; XIV, p. 766
Great Western	Q	22	31 N.	6 W.	12 mi. SW. Redding	XXIX, pp. 30-31
Green	Q				3½ mi. W. French Gulch	XII, p. 249; XIII, p. 358. See Tom Green under "T" also
Greenhorn	Cu	6	32 N.	7 W.	23 mi. NW. Redding, Greenhorn Mining Co.[4] 2135 Sacramento St., San Francisco[4]	XVII, p. 518; XX, p. 433; XXII, p. 149; XXIX, p. 30. See text this report
Grey Eagle	Q	10	29 N.	10 W.	1 mi. S. Knob	XIV, p. 789
Grubstake	P	22	36 N.	5 W.	1 mi. S. LaMoine	XVII, p. 525; XXII, p. 186
Gypsy Gold & Silver	Q				2 mi. SW. Shasta	XII, p. 249; XIII, p. 358
Halcyon	Q	17	33 N.	7 W.		XIV, p. 789; XXIX, pp. 30-31
✓ Hall Bros.	Q	2, 11	31 N.	6 W.	H. T. Hall & E. E. Hall, Redding	See text this report
Hall's	Q				10 mi. NW. Ono	XIII, pp. 358-59
Happy Jack	Q	28, 33	32 N.	6 W.	H. H. Shuffleton, Jr., 2078 Butte St., Redding	XIV, p. 770; XVII, p. 522; XXIX, p. 31
Hardscrabble (Piety Hill)	P	27, 34, 35	31 N.	6 W.	At Igo, Happy Valley Land & Water Co., Olinda[4]	XII, p. 249; XIII, p. 359; XIV, p. 789; XXII, p. 186. See text this report
Harrison Gulch						XIII, p. 359; XXIX, p. 31. See Midas also
Hartford	Cu				3 mi. N. of mouth of Potem Cr.	Bull. 50, p. 108; XIV, p. 766
Hartman	Q				3½ mi. N. Schilling	XII, p. 250; XIII, p. 359
Hazel Gold Min. Company						See Gladstone
Hein Bros.	R	6	31 N.	4 W.	Hein Bros., c/o J. H. Hein, Red Bluff	See text this report
Hiatt						See Gladiator
Hidden Treasure	Q				8 mi. NE. Shasta	XII, p. 250; XIII, p. 359
Highgrade Lead	Pb	27	34 N.	1 W.		XXII, p. 193. See text this report
Highland	Q	35	33 N.	6 W.	Iron Mt. Investment Co.,[4] 351 California St., San Francisco	XIX, p. 136
Highland	Q	9, 10	33 N.	7 W.	3 mi. N. French Gulch	XIV, p. 789; U.S.G.S. Bull. 540, p. 69. See text this report
Highland Lake	Q	12	37 N.	6 W.	Philip Munko, Castella	See text this report
Hoboe	Q	17	33 N.	7 W.	Near French Gulch	XXIX, p. 31
Holman	Q				2 mi. SW. Copley	XIII, p. 359
Holt & Gregg	Cl	17	30 N.	4 W.		XIV, p. 756; XXII, p. 131
Holt & Gregg	Ls	34	34 N.	5 W.	2 mi. NW. Kennett, U. S. Smelting & Refining Co., c/o E. A. Hamilton, 921 Newhouse Bldg., Salt Lake City, Utah[4]	XIII, p. 632; XIV, p. 806. See Backbone Gold Mining Co. in text this report
Hope	Q	8	32 N.	7 W.	5 mi. SW. French Gulch	XIV, p. 790
Hornet	Pyrite	35	33 N.	6 W.	Near Iron Mountain, The Mountain Copper Co.,[4] Ltd., 351 California St., San Francisco	XVII, pp. 525-26. See Mountain Copper Co. also
✓ Horstman	Q	9	31 N.	5 W.	A. Horstman Estate, Redding	See text this report
Houston, Sam						See under "S"

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Hoy	Cr	15	37 N.	5 W.	3 mi. SW. Sims	Bull. 76, p. 183
Hull & Murray	Q				4 mi. N. Shasta	XII, p. 250
Ida Chrome	Cr	25	37 N.	5 W.	On Campbell Creek near Sims	Bull. 76, p. 183
Igo Mining Corp.						See Russell
Igo Placer Min. Co.	P	34 (?)	31 N.	6 W.	Near Igo	XXIX, p. 63. See text this report
Independence	Q	4 32	29 N. 30 N.	10 W. 10 W.	Near Knob	XXIX, p. 31
Index	Q	6	32 N.	6 W.	½ mi. N. Oak Bottom	XIX, p. 57; XXII, pp. 174-75
Indiana	Q				Near Copley	XIII, p. 359
Indiana & Last Chance	Cu, Q	29	33 N.	5 W.	½ mi. N. Copley	XIII, p. 359; XIV, p. 766
Indian Girl						See White Girl
Inez	Q	19, 20	32 N.	5 W.	¾ mi. SW. Keswick	XIV, p. 790
Ingersoll (Peerless)	Cu	25, 36	33 N.	6 W.	2 mi. W. Copley	Bull. 50, p. 114; XIV, p. 766
Iron Mask	Q	30, 31	33 N.	6 W.		See Evening Star
Iron Mountain						See Mountain Copper Co.
Isabel & Queen	Q	8	32 N.	6 W.	Near Schilling	XXIX, pp. 31-32
Jackson						See Billy McCormick
Janice	Q	11, 12	32 N.	6 W.	3 mi. NW. Keswick	XVIII, p. 598
Jenkins & Taylor	P				3½ mi. N. French Gulch	XXII, pp. 188-89
Jennings	Fe	7, 8	35 N.	3 W.	NE. side Hirz Mountain	XXII, p. 190
Jensen	Q	24	31 N.	6 W.	10 mi. SW. Redding, Alfred E. Jensen, 320 Market St., San Francisco[4]	XXIX, p. 32
Jerusalem	Q	9	31 N.	8 W.		XIII, p. 360
J.I.C.	Q	13	33 N.	7 W.	3 mi. NE. French Gulch	XII, pp. 250-51; XIII, p. 360; XIV, p. 790. See Gladstone also
Jim Fisk	Q	15	31 N.	6 W.	3 mi. N. Igo. Frances Klapetsky, 532 Nebraska Ave., Long Beach[4]	XII, p. 251; XIII, p. 360; XXIX, p. 32
Joe Davis	Q				11 mi. W. of Ono	XIII, p. 360
Jones						See Black Spider
✓ Jones, Leslie	Pb, Zn	5, 6	30 N.	6 W.	Leslie Jones, Thelma L. & Vivian A. Jones, Igo[4]	See text this report
Jubilee	Q	23	31 N.	6 W.	½ mi. from Centerville	XIV, p. 790
Jumbo	Q	18	31 N.	5 W.	6 mi. SW. Redding	XVII, pp. 522-23; XXIX, pp. 32-33
Jumping Jack	Cu	24, 25	33 N.	6 W.	3 mi. W. Copley	Bull. 50, p. 85; XIV, p. 767
Kanaka	Q	28	32 N.	6 W.	9 mi. W. Redding	XXIX, p. 33
Keane	Cu	4	36 N.	3 W.	E. of McCloud River	XXII, p. 149
Keystone	Cu					See Mammoth
King Copper	Cu				2½ mi. S. Shasta King	Bull. 50, p. 84; XX, p. 447; XXII, p. 162. See Shasta King also
Kit Carson	Q	3	32 N.	5 W.	2½ mi. SE. Copley	XIV, p. 790
Kosk Creek	Co	24 22	37 N. 38 N.	1 W. 1 E.		VII, p. 191; XXII, p. 137. See text this report
Kosk Creek	Cu	23	37 N.	1 W.	Near "Big Bend" of Pit River	XIII, p. 63; XX, p. 433; XXII, p. 150; Bull. 50, p. 108
Lacomia	Q	1	35 N.	6 W.	7 mi. W. Delta	XIV, p. 790
Last Chance	Q					XVIII, p. 296
Last Chance	Q				2½ mi. NE. Igo	XII, p. 251
Liberty	Q	31 36	33 N. 33 N.	5 W. 6 W.	1½ mi. W. Copley	XIV, p. 790
Little Castle Creek	Cr	2	38 N.	4 W.	L. H. & M. M. Brown, Dunsmuir	See text this report. Bull. 76, pp. 183-88; XIV, p. 755
Little Maud	Q				7 mi. from Shasta	XIII, p. 361
Little Nellie	Cu	27, 35	33 N.	6 W.	Near Iron Mountain	X, pp. 634-35; XX, p. 433; XXII, p. 150. See Mountain Copper Co.

Footnotes are at end of table.

TABLE OF MINES AND PROSPECTS, SHASTA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST

Name	Kind of mine[1]	Location			Remarks[2] (Location or ownership)	References to reports of State Mineralogist
		Sec.	Twp.	Range		
Live Oak	Q				4 mi. N. Redding	XIII, p. 361
Lodi	Q	16	31 N.	6 W.	3½ mi. N. Igo	XII, p. 252; XIII, p. 361; XIV, p. 791
Loftus Barytes	Ba					XVII, p. 515; XXII, p. 130. See Glidden also
Lone Cedar (Garfield)	Q	34	33 N.	5 W.	10 mi. N. Redding	XXIX, p. 34
Lone Pine	Cr	13	37 N.	5 W.	2 mi. W. Sims	Bull. 76, p. 188
Loraine	Cu	7, 8	33 N.	5 W.	4 mi. W. Coram	Bull. 50, p. 87; XIV, p. 767
Los Andes	Q					XXIX, p. 34. See Clipper & Snyder
Lost Buck	Q				6 mi. NW. Ono	XII, p. 252; XIII, p. 361
Lost Channel						See Russell
Lost Desert	Cu					See Shasta King
Luce	Co	20	33 N.	1 W.	3 mi. NE. Oak Run	VII, pp. 149-50, 191; XXII, p. 135
Lucky Bart	Q				16 mi. W. Delta	VIII, pp. 569-70
Lucky Boy	Q	15	33 N.	5 W.	2 mi. S. Kennett	XXIX, pp. 34-35
Lucky Spot	P	9	33 N.	2 W.	1 mi. NW. Ingot, E. C. Frisbie and others,[4] Redding	XXIX, p. 67
Lyons	Q	22	33 N.	5 W.	10 mi. N. Redding	XXIX, p. 35
Mad Dog	Q	28	33 N.	6 W.	18 mi. NW. Redding	XXIX, p. 35
Maddox	Q	28	33 N.	6 W.	5 mi. N. Schilling, Mad Ox Min. Co., c/o Grace Schilling, 1262 Pine St., Redding[4]	XI, p. 397; XII, p. 252; XIV, pp. 791-92; XXIX, p. 35, U.S.G.S. Bull., 540-A, p. 45. See text this report
Mad Mule (Banghart)	Q	31	33 N.	6 W.	5 mi. NW. Schilling, J. W. Curry and others,[4] 589 31st St., Oakland	IX, p. 38; XI, p. 397; XII, p. 252; XIII, p. 361; XIV, p. 791; XIX, p. 11; XXII, p. 175; XXIX, pp. 35-36; U.S.G.S. Bull. 540, pp. 40, 42, 52-54
Maduro	Q	20	32 N.	5 W.	1 mi. S. Keswick	XIV, p. 792
Mammoth	Cu, Zn, Q	2, 3 32, 33	33 N. 34 N.	5 W. 5 W.	Near Kennett, U. S. Smelting, Refining & Min. Co., c/o E. A. Hamilton, 921 Newhouse Bldg., Salt Lake City, Utah[4]	XIV, pp. 767-69; XX, pp. 435-38; Bull. 50, pp. 95, 97; XXII, pp. 150-54. See text this report under both gold and zinc
Mammoth	Q	33	33 N.	5 W.	In Old Diggings District, U. S. Smelt. & Ref. Co. See address just above	VIII, p. 568; XI, p. 397; XII, p. 252; XXIX (with map of district), p. 41. See Old Diggings also
Manlove	Q				3½ mi. N Schilling	XII, p. 252; XIII, p. 362
Manzanita						See Ballou
Marshall & Walters	Cu	14, 15	33 N.	6 W.	4 mi. W. Coram	XIV, p. 769
Martin						See Truscott
Mascot						See West End
McCall	Q	32	36 N.	5 W.	7 mi. SW. Delta	XIV, p. 792
McCarthy, Saeltzer & Smith	Q				4½ mi. NW. Redding	XIII, p. 361
McClure (Pioneer)	Cu	9, 16	34 N.	3 W.	1½ mi. N. Copper City	XIV, p. 769; XX, p. 438; Bull. 50, p. 110; XXII, p. 154
McKinnon	Q	6	35 N.	5 W.	7½ mi. W. Delta	XIV, p. 792
Mechado	Q				3 mi. NE. Igo	XII, p. 252; XIII, p. 362

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Menzel	Q	31	33 N.	5 W.	10 mi. NW. Redding, Wm. Menzel Co., c/o Wm. B. Menzel, Redding[4]	XIV, p. 797; XXIX, p. 37. See text this report
Merry Mountain	Q	1, 2	32 N.	7 W.	E. G. Chandler, Sec., 723 Balboa Bldg., San Francisco	See text this report
Metallic Extraction & Engineering Co.		12	29 N.	4 W.	R. R. Couls, Mgr., Cottonwood	See text this report
Midas	Q	3, 4, 10	29 N.	10 W.	52 mi. SW. Redding, Adele Moore, Knob[4]	Pre. Rep. No. 8, p. 18; XIV, pp. 792, 803; XXII, pp. 173-74; XXIX, p. 31. See text this report
Midland Dredge	P	4	29 N.	5 W.	10 mi. W. Cottonwood	XXXIV, pp. 118-19
Miles & Westover	Cr	14, 34	37 N.	5 W.	Near Sims	Bull. 76, p. 188
Miles, D. E.	A	36	38 N.	5 W.	5 mi. N. Sims	XIV, p. 755; XXII, p. 128
Milkmaid & Franklin	Q	16	33 N.	7 W.	3 mi. NW. French Gulch, Western Exploration Co.,[4] c/o Grant Smith, 657 Mills Bldg., San Francisco	XIV, pp. 793-94; XVIII, pp. 43, 406-07; XIX, p. 11; XXII, pp. 175-76; XXIX, p. 37. U.S.G.S. Bull. 540, pp. 35, 61, 63, 64. See text this report
Mineral Mountain	Cu	13	32 N.	6 W.	3 mi. S. Iron Mountain	Bull. 50, p. 84; XIV, p. 769
Miner's Dream	Q				3½ mi. S. Shasta	XII, p. 252; XIII, p. 362
Miner's Group of Mines (Brunswick)	Q	20	33 N.	7 W.	5 mi. W. French Gulch	XIII, p. 351; XIV, p. 780. U.S.G.S. Bull. 540, pp. 35, 37, 68. See text this report
Minneshasta	Q	33	32 N.	5 W.	4 mi. W. Redding	XVII, p. 523
Minnesota (Rattler)	Q	1, 2	32 N.	6 W.	2 mi. SW. Copley, Stephen Girard, Matheson[1]	X, p. 635; XII, p. 255; XIII, p. 363; XIV, p. 794; XXIX, pp. 37-38. See text this report
Minnie Haley	Cu	24	34 N.	4 W.	1½ mi. NE. Heroult	XIX, p. 92; XX, p. 439; XXII, p. 154
Mocking Bird	Q				14 mi. SW. Redding	XII, p. 253
Moline	Q				3 mi. N. Shasta	XIII, p. 362
Molly Gibson	Q	4, 5	29 N.	10 W.	Near Knob	XXIX, p. 38
Morris	Cu	10	34 N.	3 W.	2 mi. N. Bully Hill	XIV, p. 769
Morton & Bliss	Q	1	33 N.	6 W.	6½ mi. W. Kennett	VIII, p. 564; XI, pp. 398-99; XIV, p. 794
Mountain Copper Company, Ltd.	Q, Cu, Pyrite, Fe	34, 35	33 N.	6 W.	17 mi. NW. Redding, The Mountain Copper Co., Ltd., 351 California St., San Francisco[4]	VIII, pp. 566-67; X, p. 633; XII, p. 377; XIII, p. 63; XIV, pp. 769-70; XX, pp. 440-45; Bull. 50, pp. 70-78; XXII, pp. 154-60; XXVII, pp. 129-38; XXIX, pp. 38, 39 (map included). See text this report
Mountain Monarch	Cu	28, 33	32 N.	6 W.	2 mi. S. Schilling	XIV, p. 770; XX, p. 445; XXII, p. 160. See Happy Jack also
Mountain Queen	Q	30	32 N.	5 W.	½ mi. E. Shasta	XXIX, pp. 39-40
Mountain Top	Q				5 mi. W. Redding	XIII, p. 362
Mountain View	Q	10	32 N.	5 W.	8 mi. N. Redding	XVIII, p. 354
Mount Pleasant	Q	32	32 N.	5 W.	1 mi. W. Redding (?)	XIV, p. 794
Mount Shasta	Q	33	32 N.	6 W.	3 mi. S. Schilling, H. H. Shuffleton, Jr.,[4] Redding	XIV, p. 794; XXIX, p. 38
Mount Shasta Silica	D	2, 3 22, 23, 24	36 N. 37 N.	2 E. 3 E.	15 mi. N. Burney	XXII, pp. 163-66. See text this report
Moxley	Ls	13	34 N.	4 W.	Near U. S. Fish Hatchery	XXII, pp. 194-95. See text this report
Muletown Con.						See Potosi
Murray	Q	18	32 N.	5 W.	1½ mi. N. Keswick (?)	X, p. 365; XII, p. 253; XIII, p. 362; XIV, p. 795
National (Veteran, Forbes)	Q	23	33 N.	5 W.	10 mi. N. Redding	XXIX, p. 40. See text this report
Nellie & Annie	Q	1, 2	33 N.	7 W.	5 mi. N. French Gulch	XIV, p. 795
Nelson	Q				7 mi. N. Stella	XII, p. 253; XIII, p. 362
New Year & Australian	Q				1½ mi. N. Shasta	XIII, p. 362-63
New York & Skylark	Q	17	33 N.	7 W.	4 mi. NW. French Gulch	XIV, p. 795

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TABLE OF MINES AND PROSPECTS, SHASTA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST

Name	Kind of mine[1]	Location			Remarks[2] (Location or ownership)	References to reports of State Mineralogist[3]
		Sec.	Twp.	Range		
Niagara	Q	1, 6, 7, 8, 15, 18	33 N.	7 W.	4½ mi. NW. French Gulch, Niagara Summit Mining Co.,[4] c/o W. D. Tillotson, Box 68, Redding	X, pp. 636-37; XI, p. 50; XII, p. 253; XIII, p. 363; XIV, p. 795; XVIII, pp. 43, 296; XX, p. 15; XXIX, pp. 40-41; U.S.G.S. Bull. 540, pp. 35, 37, 44, 67. See text this report
Noble Electric Steel	Cr	13, 24	37 N.	5 W.	2 mi. W. Sims	Bull. 76, p. 188. See Pit River Consolidated also
Noble Electric Steel	Fe	21, 25, 26, 35	34 N.	4 W.	Near Heroult	XIV, pp. 805-06; XXII, pp. 190-91. See text this report
North Star	Q	15	31 N.	6 W.	12 mi. SW. Redding	XXIX, p. 41
North Star	Q	18	31 N.	6 W.	4 mi. NW. Igo	XII, p. 253; XIV, p. 796
North Star	Q	9	33 N.	7 W.	25 mi. NW. Redding	XVII, p. 523; XXIX, p. 41
North Star	Q	6	32 N.	6 W.	Near Schilling	XVII, p. 523
Oaks	R	25, 26	31 N.	5 W.	G. E. Oaks, 1341 Yuba St., Redding	See text this report
Ohio	Cu	12	33 N.	6 W.	5 mi. W. Coram	XIV, p. 770; XX, p. 445; XXII, p. 160
Old Diggings District	Q	3, 4 33, 34	32 N. 33 N.	5 W. 5 W.	9 mi. N. Redding	XXII, p. 168; XXIX, pp. 41-42 (with maps). See text this report
Old Glory	Zn				5½ mi. NE. Ingot	XXII, pp. 215-16
Old Massachusetts	Q					XVIII, p. 495
Old Spanish (Deakin & Taylor)	Q	31	32 N.	5 W.	4 mi. W. Redding, B. M. Newcomb and others,[4] 2309 Vine St., Berkeley	XII, pp. 246-47; XIII, p. 353; X, p. 632; XIV, p. 796; XXIX, p. 42
Olive	Q	19	32 N.	5 W.	1½ mi. SW. Keswick	XIV, p. 796
Olson Dredge	P	36	31 N.	5 W.	5 mi. S. Redding	XXXIV, p. 119
Oregon Con.	Cu	13, 14	33 N.	6 W.	6 mi. W. Copley	Bull. 50, p. 113; XIV, p. 770
Oro Fino	Q	35	32 N.	6 W.	1 mi. W. Shasta, Mary Behrens, 1520 West St., Redding[4]	XI, p. 44; XIV, p. 796; XXIX, p. 42
Oro Grande	Q	5	31 N.	5 W.	4 mi. W. Redding	XXIX, pp. 42-43
Oro Vista	Q	36	32 N.	6 W.	½ mi. SE. Shasta (?)	XIV, p. 796
Pacific Mineral Corporation	Zn, Cu				At Kennett	XXII, p. 216
Peerless (Anavina)	Q	23	31 N.	6 W.	8 mi. SW. Redding	XII, p. 245; XIII, p. 349; XVIII, pp. 598-99
Peterson (Deep Pit)	Fe	36	34 N.	4 W.	½ mi. S. Heroult	XXII, p. 192. See text this report
Philadelphia & Roosevelt	Q	17	33 N.	7 W.	4 mi. NW. French Gulch	XXIX, pp. 43-44. See St. Jude also
Phoenix	Q	15, 16	32 N.	6 W.	Henry Roberts, Schilling	See text this report
Pilot Dredging Co.	P	5 (?)	30 N.	5 W.	Charles England, Redding	See text this report
Pioneer						See McClure
Pioneer Dredge	P	18, 19	30 N.	5 W.	15 mi. SW. Redding	XXXIV, pp. 119-120
Pit River	Cu	25	34 N.	3 W.	3½ mi. NE. Copper City	XIV, pp. 770-771
Pit River Con.	Mn	1 36	33 N. 34 N.	4 W. 4 W.	1 mi. SE Heroult Smelter	XIV, p. 807; Bull. 76, pp. 80-81; XXII, p. 199
Polkingham	Cu	11	33 N.	2 W.	1 mi. S. Ingot	Bull. 50, p. 111; XIV, p. 771
Popejoy	Cu	25	34 N.	3 W.	3 mi. NE. Copper City	XIV, p. 771

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Porcupine	Q	35	32 N.	6 W.	10 mi. W. Redding	XXIX, p. 44
✓Potosi	Q	15	31 N.	6 W.	Potosi Land and Min. Co., c/o Abner Baldwin,[4] 304 Foothill Blvd., Oakland	XII, p. 254; XIII, p. 363; XIV, p. 796; XXIX, pp. 44-45. See text this report
Princess	P	25, 26	31 N.	6 W.	1 mi. S. Centerville	XIV, p. 797
Pugh & Lindsay	Q				3 mi. W. Shasta	XII, p. 254; XIII, p. 363
Quartz Hill						XII, p. 254; VIII, p. 570. See Cons. Kascinaska also
Rattler						See Minnesota
Rattlesnake	Q	8	31 N.	5 W.	5 mi. W. Redding	XXIX, p. 46
Rawhide	Q	19	32 N.	5 W.	2½ mi. from Keswick	XVII, p. 523
Red Bluff	Q				15½ mi. NW. Ono	XIII, p. 363
Red Cloud	Q				4 mi. W. Igo	XII, p. 255; XIII, p. 363
Redding Brick & Tile	Cl	19	31 N.	5 W.		XIV, p. 756; XXII, p. 131
Redding Con. of Nevada						See Boswell
Redding Homestead	Cl					XXII, p. 131
Red Hill	P	1	30 N.	7 W.	½ mi. NE. Ono	XII, pp. 255-56; XIV, p. 797
Reid	Q	3	32 N.	5 W.	8 mi. N. Redding, McCormick Saeltzer Co.,[4] Redding	XIV, p. 797; XVIII, p. 408; XIX, p. 11; XX, p. 15; XXII, pp. 176-78; XXIX, pp. 46-48. See text this report under "Old Diggings"
Remonia, D. & B.						See Colorado
Reservoir & Offset						See Black Cloud & Red Cloud
Richmond	Q				3½ mi. W. Igo	XII, p. 256; XIII, p. 364
✓ Richstrike Gold Mines, Ltd.	Q	7	31 N.	5 W.	R. C. Dempster, Supt., Redding	See text this report
Rickard	Q				5½ mi. W. Delta	XIII, p. 364
Riley & Bliss						See Morton & Bliss
Roaring River Dredge	P	4, 5	29 N.	6 W.	15 mi. W. Cottonwood	XXXIV, pp. 120-22
Roseman	Cu	3 34	33 N. 34 N.	4 W. 4 W.	6 mi. E. Kennett	Bull. 50, p. 109; XIV, p. 771
Ruby & Pearl	Q	4	38 N.	5 W.	12 mi. W. Castella	XIV, p. 797; XVIII, p. 354; XIX, p. 11; XXVII, p. 53
Russell	P	3, 4	30 N.	6 W.	At Igo, F. H. Russell, Redding[4]	XIV, p. 791; XVIII, p. 599; XXII, pp. 186-87; XXIX, p. 70. See text this report
Salt Creek	Q				4½ mi. NW. Redding	XII, p. 256
Sam Houstan	Q	34	33 N.	5 W.	2 mi. E. Copley	XIV, p. 797; XXIX, p. 48
Sanders & Vollmer	Q				5½ mi. W. Delta	XIII, p. 364
Savage & Dodson Dredge	P	3	29 N.	6 W.	15 mi. W. Cottonwood	XXXIV, p. 122
Schlosser	Mo	33	37 N.	5 W.	Mrs. Jennie Schlosser,[4] Box 162, Mount Shasta	See text this report under molybdenite
Schwab & Taylor						See Old Diggings
Scottish Chief	Q	31	33 N.	5 W.	½ mi. NW. Copley	XIII, p. 351; XIV, p. 797. See Menzel also
Scott, J. H., Co.						See Halcyon, Milkmaid, Washington
Shasta Belmont	Cu	24	34 N.	4 W.	On Horse Mountain	XX, p. 445; XXII, p. 160
Shasta Cement Materials Ass'n	Ls	14, 16, 23	34 N.	4 W.	Near U. S. Fish Hatchery, D. V. Saeltzer, Trustee,[4] Redding	XXII, p. 195. See text this report
Shasta Dredging Company	P	31, 32	31 N.	5 W.	SW. Redding	Bull. 57, p. 216; XIV, p. 798
Shasta Iron Co.	Fe, Ls	26	34 N.	4 W.	Near Heroult, Shasta Iron Co.,[4] 384 2d St., San Francisco	XII, p. 327; XIV, pp. 805-06; Bull. 38, pp. 301-04; XXII, pp. 192, 195-97; U.S.G.S. Redding Folio; Bull. 213, pp. 130, 219; Bull. 225, p. 178. See text this report
Shasta King	Cu	11, 12	33 N.	6 W.	7 mi. W. Kennett, The Trinity Corp.,[4] c/o Richard Burton, Box 30, Astor Station, Boston, Mass.	Bull. 50, p. 87; XIV, p. 771; XX, p. 445; XXII, pp. 160-61
Shasta May Blossom	Cu	14	34 N.	3 W.	1 mi. N. Winthrop	XIV, p. 772; Bull. 50, p. 100; XIX, p. 91; XX, p. 446; XXII, p. 161

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Name	Kind of mine[1]	Location			Remarks[2] (Location or ownership)	References to reports of State Mineralogist[3]
		Sec.	Twp.	Range		
Shasta National Copper	Cu	18, 19, 20	34 N.	5 W.	6 mi. NW. Kennett	XX, p. 446; XXII, p. 161
Shasta Superior						See Boswell
Shasta View (Bonanza Gold Dollar)	Q	26, 27, 34, 35	32 N.	6 W.	2 mi. W. Shasta	XVIII, p. 256; XX, p. 15; XXIX, pp. 48-49
Shasta Zinc & Copper Co.	Cu, Zn				At Bully Hill	XVII, p. 519. See Bully Hill also
Silver Falls-Chicago Con.	Ag	17, 18, 19, 20	31 N.	6 W.	4 mi. NW. Igo, L. Elizabeth Bass,[4] and others, Redding	XIV, p. 798; XVII, pp. 527-28; XXII, pp. 207-10. See text this report
Silver King	Ag	16 (?)	31 N.	5 W.	4 mi. W Redding, G. B. Wood, Redding	XI, p. 44; XVII, p. 528. See text this report
Siskiyou & Nightingale	Q	2	35 N.	6 W.		XIV, p. 798
Slatonas	Q				4 mi. W. Delta	XIII, p. 364
Slattery & Welch	P	8	33 N.	6 W.	5 mi. NE. French Gulch	XIV, p. 798
Slide	Q	7, 8	32 N.	5 W.	1 mi. N. Keswick	XIV, p. 799
Snyder						See Clipper
Soupan Hot Springs	MS				At Lassen Peak	XXII, p. 200; U.S.G.S. Water-Supply Paper 338. See text this report. See Supan under sulphur also
Southern Pacific	Cl	19	32 N.	4 W.		XIV, p. 756; Bull. 38, p. 257; XXII, p. 131
South Star	Q	32	33 N.	7 W.		XVIII, p. 256
Spardy	Q				2½ mi. SW. Copley	XII, p. 257; XIII, p. 364
Spread Eagle	Cu	13	33 N.	6 W.	4 mi. W. Coram, U. S. Smelting & Refining Co., 921 Newhouse Bldg., Salt Lake City, Utah[4]	Bull. 50, p. 85; XIV, p. 772. See Mammoth also
Spring Gulch	Q				7½ mi. NW. Schilling	XII, p. 257; XIII, p. 364
Spring Gulch Mining Co.						See Potosi; also North Star
Star Gulch Mining Co.						See Walker
Stevenson	Cu	14	33 N.	6 W.	3½ mi. W. Coram	XIV, p. 772
Stewart & Moore	D	20	31 N.	1 E.	29 mi. E. Anderson	XXII, p. 166
St. John	Zn	30	34 N.	1 W.	5½ mi. NE. Ingot	XXII, p. 216
St. Jude	Q	17	33 N.	7 W.	A. P. Robillard, French Gulch	XXIX, pp. 43-44. See text this report
Stock Asbestos	A	1, 2, 33, 34	37 N. 38 N.	5 W. 5 W.	6 mi. NW. Sims, Sarah L. Stock, 1200 E. Ocean Ave., Long Beach[4]	XIV, pp. 752-55; XXII, p. 128. See text this report
Stowell (Grab)	Cu	14	33 N.	6 W.	4 mi. W. Coram	X, p. 633; XIII, pp. 364-65; Bull. 50, p. 85; XIV, p. 772. See Mammoth also
Sugarloaf & Homestake	Pb, Zn	4	33 N.	2 W.	C. A. Hill, Ingot, and Chas. Walters, Montgomery Creek	See text this report
Sugar Loaf (Galvin)	Cu	25, 26	33 N.	6 W.	On Sugar Loaf Mountain	Bull. 50, p. 84; XIV, p. 772
Sulphide	Cu	16	32 N.	6 W.	½ mi. from Schilling	XIV, p. 773
Summit						See Sunny Hill
Summit	Cu	30	34 N.	5 W.	4 mi. NW. Kennett	Bull. 50, p. 97; XIV, p. 773; XX, p. 447; XXII, p. 162
Summit & Montezuma	Q	17	33 N.	7 W.	5 mi. W. French Gulch	X, p. 641; XIII, p. 365; XIV, p. 799; XVIII, pp. 206, 256; XXIX, pp. 49-50. See text this report

Footnotes are at end of table.

Sunday Gulch	Q	10	29 N.	10 W.	3 mi. SE. Knob	XIV, p. 799
Sunny Hill (Summit)	Q	1	30 N.	8 W.	7 mi. W. Ono, Sunny Hill Mining Co.,[4] c/o L. F. Barlow, 1355 McKendrie St., San Jose	X, p. 641; XI, p. 51; XII, p. 257; XIII, p. 365; XIV, p. 799; XXIX, p. 50
Sunshine						See Kanaka
Supan	S	21, 22	30 N.	4 E.	Milton Supan and others,[4] Red Bluff	See text this report
Surprise	Q				1½ mi. N. Shasta	XII, p. 257
Sutro	Cu					See Mammoth
Sybil	Q	7	33 N.	7 W.	5 mi. NW. French Gulch	XIV, p. 777; XVIII, pp. 43, 138, 296, 408; XIX, p. 11; XXII, pp. 178-79; XXIX, pp. 50-51. See text this report. U.S.G.S. Bull. 540, pp. 68-69.
Tabowie	Q	10, 15, 16	33 N.	7 W.	At French Gulch	See text this report
Tanglefoot	Q	12	30 N.	8 W.	8 mi. SW. Ono	XIV, pp. 799-800
Texas	Q	32, 33	33 N.	5 W.	9 mi. N. Redding, Evelyn P. Joslym, Florence D. Lackey, Daniel McIntyre,[4] c/o W. D. Tillotson, Redding	X, pp. 629-30; XI, pp. 43, 396-97; XII, p. 258; XIII, pp. 365-67; XIV, p. 800; XVIII, p. 206; XIX, pp. 11, 58, 137; XXII, p. 179; XXIX, pp. 51-52. See "Old Digings" also
Thompson	Q, Cu	34	33 N.	4 W.	Estate of Sarah E. Thompson, Redding	See text this report
Thompson	Q				2½ mi. SW. Shasta	XI, p. 40; XII, p. 258; XIII, p. 367
Three Sisters	Q	15	33 N.	7 W.	2 mi. NW. French Gulch	XIII, p. 367; XIV, p. 800
Tom Green	Q	17 (?)	33 N.	7 W.	5½ mi. W. French Guich	XII, p. 249; XIII, p. 358; XIV, p. 800; XXIX, pp. 52-53. See text this report
Topknot	Q				5½ mi. from Delta	XIII, p. 367
Trinity Consolidated	Q	1, 2	35 N.	6 W.	W. of Delta, Howard S. & Jno. Z Anderson, 340 N. 1st St., San Jose, Regis E. Halter, Redding[4]	VIII, p. 569; XIII, p. 367; XIV, p. 802. U.S.G.S. Bull. 540, pp. 35, 37, 54, 55
Triple "S"	P				Near Pollock, Geo.E. Morrill, 116 Hamlet St., Los Angeles	No published reports
Truscott	Q	36	33 N.	7 W.	Mrs. John Martin, Redding	VIII, pp. 571-72; XII, p. 248; XIII, p. 356; XIV, p. 802; XXIX, pp. 53-54
Tuff						XIV, p. 808
Uncle Sam	Q	1 6	33 N. 33 N.	6 W. 5 W.	Dakin Co. and Estate of Alice R. Goodfellow, Redding[4]	X, p. 639; XI, pp. 47, 395, 398; XII, pp. 258-59; XIII, pp. 367-68; XIV, pp. 802-03; XIX, p. 56; XX, p. 15; XXIX, pp. 54-55. See text this report
Union Forest Queen	Cr	22	37 N.	5 W.	4 mi. NW. Gibson, Antone Orsini, Redding	Bull. 76, pp. 181-82. See text this report
U. S. Smelting, Refining & Mining Exploration Co.	Cu	2, 3 29, 31 32, 33	33 N. 34 N.	5 W. 5 W.	Near Kennett, Address: c/o E. A. Hamilton, 921 Newhouse Bldg., Salt Lake City, Utah[4]	XIV, pp. 767-69; XX, pp. 435-38; XXII, pp. 150-54; XXIX, pp. 55-56; Bull. 50, pp. 95, 97. See Mammoth also
Utah & California						See Walker
Vera Mines						See Uncle Sam
Vergnes	P	7, 17	32 N.	6 W.	At Oak Bottom	XXIX, pp. 72-73
Veteran						See National
Victor	Q	3	29 N.	10 W.	At Knob	X, pp. 635-36; XI, p. 50; XII, p. 260; XIII, p. 368; XIV, pp. 803; XXIX, p. 31
Vogt						See St. Jude

Footnotes are at end of table.

TABLE OF MINES AND PROSPECTS, SHASTA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST

Name	Kind of mine[1]	Location Sec.	Location Twp.	Location Range	Remarks[2] (Location or ownership)	References to reports of State Mineralogist[3]
Walker's, Frank	Q				4 mi. W. Redding	XVIII, p. 296
Walker (Utah & California)	Q	3, 4	32 N.	5 W.	Dowling Mining & Investment Company[4]	X, pp. 630-31; XI, p. 397; XII, p. 259; XIII, p. 368; XIV, p. 803; XXIX, p. 56. See text this report. See Old Diggings
W. and W.	Q	19	32 N.	5 W.	1 mi. W. Keswick	XVII, pp. 523-24
Washington	Q	16	33 N.	7 W.	Geo. Grotefend, Redding[4]	X, pp. 635-36; XI, p. 50; XII, p. 260; XIII, p. 368; XIV, pp. 774, 804; XVIII, p. 43; XIX, p. 11; XXII, pp. 179-80; XXIX, p. 57. U.S.G.S. Bull. 540, pp. 35, 37, 44, 64-66. See text this report
West End	Q	16	32 N.	6 W.	1 mi. SE. Schilling, Chas. Harvey, 62 Fellsway,[4] Boston, Mass.	XII, p. 260; XIII, p. 368; XVIII, pp. 96, 256, 295-96, 409-10; XIX, p. 11; XXII, p. 180
Western						See Milkmaid & Franklin
West Point	Q				3½ mi. from Shasta	VIII, p. 570; XII, p. 260; XIII, p. 368
White Girl & Indian Girl	P	9	31 N.	5 W.	Adella Gay, Berkeley[4]	See text this report
White Oak					2½ mi. NE. Shasta	VIII, p. 571
White Star (Crystal)	Q, Ag	20	31 N.	6 W.	3 mi. NW. Igo	XIV, p. 784; XXII, p. 210. See text this report
Williard & Williams	Q	19	32 N.	5 W.	1 mi. E. Keswick (?)	XVII p. 523
Woodfill	Q	7	30 N.	7 W.	6 mi. W. Ono	XXIX, pp. 9-10
Woodrow Wilson	Cu	4	33 N.	2 W.	1½ mi. SW. Ingot (?)	XX, p. 447; XXII, p. 162
World's Fair	Q				2½ mi. NW. Igo	XII, p. 260; XIII, p. 368
Wyandotte Dredge	P	17	31 N.	4 W.	Near Redding	XXXIV, p. 123
Yankee John	Q	17	31 N.	5 W.	6 mi. SW. Redding	XVII, p. 524; XVIII, p. 495; XIX, p. 11; XXIX, pp. 57-58. See Richstrike also
Yellow Jacket	Q				3 mi. NE. Copley	XII, p. 260; XIII, p. 368

[1] A, asbestos; Ag, silver; Ba, barite; Cl, clay; Co, coal; Cr, chromite; Cu, copper; D, diatomite; Fe, iron; Ls, limestone; Mn, manganese; Mo, molybdenum; MS, mineral springs; P, gold placer; Pb, lead; Pt, platinum; Q, gold lode; R, crushed rock; S, sulphur; ss, sandstone; Zn, zinc.

[2] Addresses are in California unless otherwise noted.

[3] Some references to publications of the United States Geological Survey (U.S.G.S.) are included.

[4] Name and address checked against records of the Assessor of Shasta County for 1938.

a storage-battery locomotive; and several hundred feet of new crosscuts were driven. This level is connected by a vertical winze to the Friday-Lowden level, roughly 300 ft. lower in elevation. The shaft or winze is about 2500 ft. from the portal of the Mammoth 470-level, and about 3600 ft. from the portal of the Friday-Lowden level. It was repaired and equipped with a hoist. Equipment includes also a two-stage air compressor, shop, boarding house, bunk house and office at the portal of the Mammoth 470-level.

Diamond drilling to a total of several thousand feet in separate holes averaging 150 ft. to 200 ft. in length has been done. Some of the holes have been drilled from the Friday-Lowden level, and some from an intermediate from the winze. Ore giving good assays in zinc has been cut in some of these holes. The crew varies from 10 to 20 men under W. L. Taylor of Kennett.

SACRAMENTO FIELD DISTRICT

C. A. Logan, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. Laizure, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field District are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

W. B. Tucker and R. J. Sampson, Mining Engineers

On account of unfinished field work, there is no report from the Los Angeles Field District in this issue.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

In the next issue:

The July 1939 issue of the California Journal of Mines and Geology will contain two geological reports which should be of particular interest to the oil and gas industry:

The first is by Doctors Charles A. Anderson and R. Dana Russell on the Tertiary of the northern Sacramento Valley. The report is accompanied by a geologic map with cross-sections. A list and locations of the wells drilled for oil and gas in this region are also printed on the map.

The second is a report by Mr. J. E. Eaton on the geology of the Caliente Range, Cuyama Valley, and Carrizo Plain, with special reference to the structure and possibilities of finding oil and gas deposits. The area described lies partly in Santa Barbara County and partly in San Luis Obispo County.

Both of these papers represent the results of a large amount of field work done by the authors and both are entirely contributions to the Journal.

A continuation of our exhaustive bibliographic work, done under the supervision of Dr. Solon Shedd, and previously published—first as Bulletin 104, ''Bibliography of the Geology and Mineral Resources of California to December 31, 1930,'' second as Bulletin 115, which covers the years 1931 to 1936, inclusive—is to be presented in the July issue of the Journal and will cover the year 1937. This report, as well as Bulletin 115, was prepared largely by Miss Corinne Kibler. The funds were supplied by the Federal Works Progress Administration.

In addition to the above reports, a short paper on the giant Goose Lake Meteorite from Modoc County by Dr. Earle G. Linsley, is also to be included in the July issue.

For the October issue:

The concluding 1939 issue of the Journal (for October) is to contain a timely report on the quicksilver deposits of California by Alfred L. Ransome.

A large and carefully prepared map of all the known quicksilver deposits of California, together with data presented on the margin of the map, exhibit much interesting, instructive, and valuable information on the geology, mineralogy, economics, and production of this liquid metal, which represents one of the strategic metals now greatly sought after on account of the new World War situation. This map is to be distributed separately and is not to be included in the subscription of the Journal. It represents one of a series of such mineral distribution maps now in preparation by the Geologic Branch.

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

THE PUBLIC'S INTEREST IN MINE TAXATION

By A. G. Mackenzie, Salt Lake City, Utah.

It is easier to show that the state of the mining industry is a matter of general concern than it is to enlist the general public interest in the question. The facts of the mining industry are much less thrilling than the mining fictions and are not so easy to hear or read. Mining is only one of many essential industries in which the public as a whole has a vital concern, and the service rendered by mining is not so readily perceptible as the services of most of the others. Agriculture and transportation, for examples, furnish services so directly and continuously apparent that no one can escape knowledge of their importance to him. Everybody learns much about them without conscious effort.

Mining is in a very different position from industries such as these. The nonmining citizen knows little of the materials and processes which result in the commodity he uses and the commodity itself is often so utilized as to obscure its presence as a factor in his welfare. For instance, he enjoys the improved vision he obtains through his eyeglasses without knowing that their excellence is largely due to the presence of lead in the lenses. He does not know that zinc helps to give his automatic tires their long life or that copper is frequently employed to purify his water supply. The published "news" of mining is almost always restricted to the good news so that the average citizen learns only of the few conspicuous mining successes. These, he is told, result most through luck or through the misdeeds of "the capitalists" and operate solely to the benefit of "a few millionaires" of vague and distant domicile and predatory habits. Such facts as that in my state—a typical mining area—the metal mines disburse more than 80% of their gross receipts within the state, pay the equivalent of 34% of their net income in taxes and have two and a half times as many nonmillionaire stockholders as they have employees, never get to the public through these sources. Nor do such other facts as that we have several hundred mines on the tax rolls and only a half a dozen or so that pay dividends. The average citizen seldom learns of the multiplicity of rules and regulations to which the mines must conform, the voluminous, intricate and expensive reports they must prepare and file, the constant struggles with which mining men are so familiar to produce and process enough ore of sufficient grade to keep the enterprise alive. And of the countless instances where a man has put in most of his life to find and make a mine, the general public hears only of the very small proportion which make good in a large way. It always hears through press and periodicals of the desert rat who became a plutocrat over night, as perhaps one out of a million of them do, but not of the thousands of men who devote their earnings, their labors, their science and their sacrifices in long patient and undramatic efforts

to create a productive mine, although we know these are the men to make the most of the mines.

We should try to get to the public the fact that excessive taxation of mines takes money from everybody. We should endeavor to show the nonmining public that it has a direct cash interest in the question, as that is the most effective way to obtain the support of these nonmining citizens in bringing the facts forcefully to the notice of those who create and administer the tax laws. This will not be accomplished by this speech, by this speaker or by any individual or group. It is something that every mining man in the country should keep constantly in mind and he should take every opportunity to make the facts more widely known. Each one of us can tell his own story more effectively than anyone else can tell it for him, and men are always articulate when they know what they are talking about.

I have already indicated, and I recognize, that the facts of the other fellow's business are unexciting, but when they have a wide significance they appeal to thinking people. We have demonstrated this in my state, where the mining people have had several conferences recently with representatives of some of the most intelligent and influential groups of nonmining citizens, who have taken the trouble to learn much about our problems as we have tried to do about theirs. All of us have laid our cards on the table at these conferences, have agreed we have many common problems, and are endeavoring to formulate a program which we are convinced will be for the good of all of us.

In our presentation of the economic significance of mining, we can forget the man who is not tax conscious. If he is not conscious of taxation in this country today he is not conscious of anything. Not when one notes, as I did in three days of my ordinary reading recently, that purchasers pay 53 different taxes on a loaf of bread, 126 taxes on a pair of shoes and 216 taxes on gas and oil; that if all incomes of $1,000,000 or more in the United States in 1937 were turned over in their entirety to the government they would not pay expenses for forty-eight hours; that 150 large corporations in varied lines paid an average of $1.45 a share to their stockholders and an average of $2.62 a share on taxes; and that the country as a whole pays one-fourth of its total income in taxes. I have already mentioned that the metal mines in my territory pay 34% of their income in taxes, which indicate that this industry is well above the national average given.

Now let us take a look at the state of the mining industry in the United States. This need not be elaborated before a mining audience, but a statement of what has happened to us as a world producer of gold, silver, copper, lead and zinc as compared with former years will help us to see how things are going. I use the five metals named as the ones about which I am best informed and as the ones of most importance to this group.

Our proportion of the world production of these five metals shows an average today of only 26% as compared with 47% twenty years ago, a loss of almost 50%; and the downward trend has been steady. Our rank as a gold producer has declined more than 7%, as a silver producer 16%, as a copper producer more than 22% and as a zinc producer 30%.

We know this decline has not been due to exhaustion of domestic ore supplies. And we know it is not due solely to domestic taxes and their application. But we do know that taxation is one of the factors and a considerable one for the reason that taxation has become a major item in cost of production and restriction of mining investment in this country, with consequent effects on the position of the United States as a world competitor in the non-ferrous metal field.

I have just indicated something the public should know, that this country is only a part—and as I have shown, a diminishing part—of the world picture. Our producers do not and can not control the markets for their metals but must meet foreign competition or quit. Every added item of expenditure, whether taxation or anything else, imposed on the industry here strengthens the position of the foreign competitors.

Mining is the essential industry in many communities, especially in the west, vital not only to those who invest in the mines but to those employed in them and to the local public; and this interest goes far beyond the local community to take in the users of the metals, which takes in everybody. But, for the present, let us consider only the mining industry and the mining areas and say some things well known to mining people which should be made known to the rest of the public.

When taxes are such in amount or in nature that they hurt the operation and development of mines and discourage investment in them, they hurt the entire community. Unless there is enough profit in the mine investment, development and operation to justify the risk involved, the industry will not expand or prosper and the government will not obtain revenues from it or from the others in the mining communities, which will no longer exist; and the public will have to take up the slack thus created. If those now engaged in mining or those who contemplate investing or otherwise engaging in it must look to a future where too large a proportion or all of the earnings are to be taken in taxes, the incentive to continue mining is gone.

Tax methods, as well as tax volume, are part of the picture. Arbitrary definitions of income, arbitrary limitation of deductions for losses or for expenses can have the same effect as increased tax rates. Thus, proposals to take heavy taxes from profits with little or no recognition of losses, may mean that with the taxes taken by the government and the actual, though unrecognized, losses, there will be nothing at all left for the industry. Inadequate recognition of depletion means that capital as well as income is being taxed, and the same is true of adequate recognition of depreciation and of development expenses.

An allowance of the right to carry forward the losses of one year as a deduction from income of a succeeding year is essential to fair treatment of the mining industry. A mine keeps going during a period of losses because it hopes to make profits in subsequent years. If it did not have this expectation, it would shut down and quit. When it keeps going during a period of losses, these losses are as much a part of its costs as are the expenditures made during a period of profit. It is not fair for Government to take its large slice of the profits with-

out taking into account the losses which are a necessary and unavoidable part of the operation which gives rise to the profits.

It is not in the public interest to have the government or its agents look merely at the government's needs or desires for additional revenues. It is in the public interest, as well as in the interest of justice, to consider the situation of the taxpayer. When taxpayers conclude that taxes are too high, revenues fall off. Some of our contemporary statesmen and economists apparently have not found this out yet.

It is not easy to state in exact figures when taxes become too high. The taxpayers figure that out for themselves, each with reference to his individual situation, but there is a point at which each one will lose his incentive to continue ownership or operation. Beyond that point, taxes are too high and tax revenues decline. Many investors have concluded that the point has been passed in mine taxation and are looking elsewhere.

The question is not merely the situation as of today. It takes years to make a productive mine and years to recover the investment therein and derive a profit. It is especially important in such an industry that we should be able to look to the future with some sort of confidence. The sort of confidence that will be most efficacious will be based on a belief that present tax laws are fair and reasonable and that they will continue to be so. The tax record of the last few years has not instilled that sort of confidence, although the final action of the recent Congress did give some hope of a more reasonable and rational policy in the future; a hope that will vanish if the next session, or succeeding sessions, fail to show an appreciation of the taxpayer's situation and a disposition to treat him fairly and reasonably.

Confidence is not stimulated by the continual uncertainties and changes in interpretation of such statutes as the Federal Income Tax laws. An interpretation given when a transaction takes place or when the tax return is filed is often not the same when the tax return is examined and settlement has to be made. There is evidence of a straining to get interpretations that will take more money from the taxpayer, no matter how unnatural or unjust such interpretations may be, so that the taxpayer's uncertainty as to what his tax liability may ultimately be decreases his confidence and adds another element of risk to his business.

Now then, how does all this become a part of the public's interest, particularly that part of the public which is not directly engaged in mining or directly dependent upon it? Throughout the mining States, it is generally recognized that the entire community suffers if mines are not active. Even the smallest towns that sell groceries or dry goods, or hardware, or books, or any other kind of merchandise, know that their business suffers whenever mines are suffering. This is true whether they look for business directly from those who are employed in the mines or from others in their communities, for the whole community feels the effect of the mine shutdowns or curtailments. If the stores in the mining areas can not sell their goods, they do not buy, and the cotton mills of the South and printers in New York will feel the curtailment. There is no part of the country that does not feel a

curtailment of purchasing power in the mining sections. For this reason alone the entire country has a real interest in the prosperity of the mining section.

Furthermore, everybody—mining and nonmining—has to have the metals and has to pay for them. If mining costs are increased in this country, people must expect to pay more for their metals. This is true whether he is buying metals produced abroad, for the higher the price for metals produced in this country, the higher in the end will be the price here for foreign metals. We can only keep a large supply of metals continually available in this country commensurate with the risks involved, and that means profit after taking all taxes into account. Every citizen of the country, in the West or the East, the North or the South, is a consumer of metals, and, whether he realizes it or not, has a real personal interest in the mining industry.

So we have this situation: We have a well-conducted domestic industry which is a large employer of labor, a large consumer of the goods and services of others, a large taxpayer and a vital national asset. It should, as it does, bear its share of all public burdens and responsibilities, but they must not be allowed to remain excessive and those who impose them must recognize that the nature of mining makes it more sensitive and vulnerable than many other human activities. They should especially recognize that to overload this industry is not merely an injustice to it but a loss to the entire public. And the public should be shown that unless the mining industry can continue and continue on a profit basis with reasonable taxation, the public will lose money.

We should tell these things to the public in any way, in any amount and as frequently as may be indicated by the circumstances. Those who will not listen would be of no service in any event, and I believe most of those who do listen to an adequate presentation will comprehend the situation and realize that, to the extent mining does not pay, someone else must pay.

ADMINISTRATIVE

Walter W. Bradley, State Mineralogist

Personnel

Alfred L. Ransome has been appointed to the position of geological draftsman in the headquarters office of the Division of Mines in San Francisco. He is a graduate of Stanford University with advanced degrees in both geology and mining engineering, and is the son of Frederick L. Ransome, a distinguished member for many years of the staff of the U. S. Geological Survey, later on the faculty of the California Institute of Technology at Pasadena.

New Publications.

Commercial Mineral Notes (Nos. 190-192, inc.) February, March, April, 1939, respectively. These 'Notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to five pages in recent months.

Mail and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

Henry H. Symons, Statistician and Curator

STATISTICS

The counties of California have produced for some years past more than 50 different mineral substances, the total value of which was estimated at $369,751,000 for 1938. See January, 1939, issue of the California Journal of Mines and Geology.

At present (April, 1939) reports for most of the producers are in hand. Data for several substances are now complete and have been compiled, being presented herein. Information at hand indicates that there was no commercial production during 1938 of the following: antimony, asbestos, bismuth, fluorspar, graphite, manganese ore, molybdenum ore, shale oil, strontium, titanium, or tin.

There was a single producer of each of the following: bromine, garnets, magnesite, potash, pyrite, sulphur, zinc and lithia.

Reported for the first time in California's commercial list are alunogen from Corona, Riverside County, to be used as a soil conditioner; and garnet from Bishop, Inyo County, and used as an abrasive.

Two minerals returned to commercial production after several years absence are serpentine from San Bernardino County, to be used as an admix in cement and for a possible manufacture of magnesium chemicals; and lithia salts from Searles Lake.

There are three minerals that might be placed on the active commercial list in the near future. E. I. DuPont de Nemours and Company were doing development on ilmenite deposits in Los Angeles County, with intention of production of titanium for pigments and chemicals. Mr. C. Solomon, Jr., is doing work on his property near Barstow, San Bernardino County, in preparation for shipping strontium ore in the near future. A gold dragline dredge in Placer County is saving zircon sand as a byproduct in the hope of finding a market for it in the ceramics. They are making a concentrate running 98.5+% zircon which contains 66.5% $ZrO2$.

BORATES.

During 1938 there was produced in California a total of 240,899 tons of borate materials compared with 346,489 tons for the year 1937. The material shipped during the year included the new sodium borates, kernite (rasorite), Kramerite from Kern County; also crystallized borax prepared by evaporation of brines at Searles Lake in San Bernardino County and Owens Lake in Inyo County.

As the crude ore is not sold as such, but is almost entirely calcined before shipping to the refinery for conversion into the borax of commerce, and because of the fact that the material varied widely in boric acid content, we have recalculated the tonnage to a basis of 40 per cent A.B.A. This is approximately the average A.B.A. content of colemanite material after calcining, and also of the crystallized borax obtained from evaporation of the lake brines.

Recalculated as above, the 1938 production totaled 276,144 tons valued at $5,014,237. This was a decrease both in quantity and value from the 1937 output, which was 326,099 tons worth $6,206,619.

CEMENT.

During 1938 there was a production of 10,561,037 barrels of cement in California, valued at $15,502,574 f.o.b. plant, of which 4,015,467 barrels came from southern California plants, and 6,545,570 barrels came from northern California plants. The 1938 output was a decrease from that of 1937, which was 12,072,037 barrels worth $16,546,229.

Shipments during 1938 were made from ten plants in nine counties to the extent 10,594,706 barrels valued at $15,567,295, as compared with 11,721,818 barrels worth $16,868,379. There were five plants in operation in northern California—one each in Calaveras, Contra Costa, Merced, San Mateo, Santa Cruz counties, which shipped 4,006,067 barrels of cement; and five plants in southern California, two in San Bernardino County, and one each in Kern, Los Angeles and Riverside counties, which shipped 6,588,639 barrels of cement. There were 1,993 men employed in the above plants during the year 1938.

LIME.

In California during 1938 there was an output of lime amounting to 70,578 short tons valued at $683,403, coming from two plants each in El Dorado and San Bernardino counties; and one each in Alameda, Santa Cruz, and Tuolumne counties. The above figures showed an increase in both amount and value over those of 1937 which were 69,532 tons worth $681,277.

So far as we have been able to segregate the data, these figures include mainly only such lime as is used in building operations; though they do include a small portion of calcined lime employed in agriculture and the chemical industries, the figures for which were not separable. A portion is hydrated lime. Limestone utilized in sugar making, for smelter flux, as a fertilizer, and other special industrial uses, is classified under 'Industrial Materials.' That consumed in cement manufacture is included in the value of cement.

LIMESTONE.

'Industrial' limestone was produced by 21 properties in 12 counties in California during 1938 to the amount of 302,655 short tons valued at $729,149, this being a decrease in both amount and value from the 1937 output, which was 351,755 tons worth $830,562. The 1938 yield came from four properties each in El Dorado and Santa

Clara counties; two each in Santa Cruz and Tuolumne counties; and one each in Butte, Fresno, Inyo, Los Angeles, Riverside, San Luis Obispo, and San Mateo counties.

Distribution of the 1938 output of limestone was as follows:

County	*Tons*	*Value*
El Dorado	135,142	$304,420
San Bernardino	14,313	44,795
Santa Clara[b]	98,944	128,793
Butte, Fresno,[a] Inyo, Los Angeles, Riverside, San Luis Obispo, San Mateo,[b] Santa Cruz, and Tuolumne*	54,256	251,141
Totals	302,655	$729,149

* Combined to conceal the output of individual operators in each.
[a] Includes marl.
[b] Includes shells.

The amount here does not include the limestone used in the manufacture of cement nor for macadam and concrete, nor of lime for building purposes; but accounts for that utilized as a smelter and foundry flux, for glass and sugar making, and other special chemical and manufacturing processes. It also includes that utilized for fertilizers (agricultural 'lime'), 'roofing gravel,' paint and concrete filler, whiting for paint, putty, kalsomine, terrazzo, paving dust, chicken grit, carbon dioxide gas, 'paving compound,' facing dust for concrete pipe, also for rubber and magnesite mix. The material from Fresno County was marl; and that from Alameda, San Mateo and Santa Clara counties was shells, dredged from San Francisco Bay, which were ground and used for agricultural purposes and poultry grit. Of the total 'industrial' limestone produced in 1938 approximately 128,195 tons value at $310,449 was used for agricultural purposes and poultry grits.

MAGNESIUM SALTS.

During 1938 there was an output of magnesium salts in California coming from one plant each in Alameda and San Diego counties, and two in San Mateo County. This amounted to 24,176 short tons valued at $469,636, and consisted of the chloride, carbonate, hydroxide, and oxide. The 1937 output amounted to 3867 tons worth $316,669, which was also the chloride, carbonate, hydroxide, and oxide. The chloride was nearly all sold for use in magnesite stucco and cement mixtures (Sorel cement), also some for road liquor. The carbonate, a bulky white powder, was used as a heat-insulating material, as a substitute for magnesite, as a filler for rubber, paper, paint, etc., and in medicines, in tooth paste, in face powder and as a polish for metal and glass. The sulphate marketed in past years was utilized for medicinal and bath purposes. The material coming from San Diego County was residual bitterns from the salt plants and was in part marketed in the liquid form carrying from 35 to 67 $MgCl_2$ and in part as dry crystals, while that from Alameda and San Mateo counties was magnesium carbonate, manganese hydroxide, and manganese oxide, and is obtained by precipitation from sea water.

The average value reported for the chloride produced in California in 1938 was approximately $28.30 per ton, f.o.b. plant.

QUICKSILVER.

The production of quicksilver in California during the year 1938 was 12,171 flasks valued at $846,497, compared with the 1937 output

of 9,995 flasks worth $837,789. The 1938 output came from 58 properties in 16 counties and distribution was as follows:

County	Flasks	Value
Lake	3,718	$265,430
Napa	694	46,403
San Luis Obispo	1,114	77,938
Santa Barbara	104	7,179
Santa Clara	283	19,883
Sonoma	425	29,641
Contra Costa, Fresno, Inyo, Kern, Kings, Monterey, Orange, San Benito, Solano, Yolo *	5,833	400,023
Totals	12,171	$846,497

* Combined to conceal the output of individual operators.

SALT.

Most of the salt production in California is obtained by evaporation of water of the Pacific Ocean, plants being located on the shores of San Francisco, Monterey, and San Diego bays, and at Long Beach. Additional amounts are derived from lakes and lake beds in the desert regions (in part, rock salt), mainly in Imperial, Kern, and San Bernardino counties, and evaporation of alkaline lake water in Modoc County. A small amount of valuable medicinal salts has been obtained by evaporation of the water of Lake Mono, Mono County, and from a mineral spring in Butte County.

During 1938 there was an output in California of 395,746 tons of salt worth $1,099,737, compared with 370,431 tons worth $1,044,325 in 1937. There were twelve companies operating plants in 1938; two in San Bernardino County and one each in Alameda, Butte, Imperial, Kern, Los Angeles, Modoc, Monterey, Orange, San Diego, and San Mateo.

The average value reported for salt produced in California during 1938 was $2.78 per ton f.o.b. plant, compared with $2.82 in 1937; $3.08 in 1936; $3.36 in 1935; $3.68 in 1934, and $3.89 in 1933.

SILICA (Sand and Quartz).

We combine these materials because of the overlapping roles of vein quartz which is mined for use in glass making and as an abrasive, and that of silica sand which, although mainly utilized in glass manufacture, also serves as an abrasive. Both varieties are also utilized to some extent in fire-brick manufacture.

We do not include under this heading such forms of silica as: quartzite, sandstone, flint, tripoli, diatomaceous earth, nor the gem forms of 'rock crystal,' amethyst, and opal. Each of these has various industrial uses, which are treated under their own designations.

The production of silica in California during 1938 amounted to 63,167 short tons valued at $278,676 f.o.b. rail shipping point, and came from two properties in Contra Costa County and one each in Monterey, Orange, Riverside, and San Diego counties. The above was a decrease in both amount and value from the output of 1937 which was 84,313 tons worth $348,987.

The glass sand came from Contra Costa, Monterey, Orange, and Riverside counties. For making the higher grades of glass, deposits in Contra Costa County are replacing the sand imported from Belgium. Belgium sand has displaced local material in the manufacture of

sodium silicate ('water glass'). There are various deposits of quartz in California which could be utilized for glass making, but to date they have not been so used owing to the cost of grinding and the difficulty of preventing contamination by iron while grinding.

Silica sand has been produced in the following counties of the State: Alameda, Amador, Contra Costa, El Dorado, Imperial, Inyo, Los Angeles, Mariposa, Mono, Monterey, Orange, Placer, Riverside, San Diego, San Joaquin, and Tulare, the chief centers being Contra Costa, Amador, Monterey, and Los Angeles counties. The industry is of limited importance, so far, because of the fact that much of the available material is not of a grade which will produce first-class colorless glass; for such it must be essentially iron-free. Even a fractional per cent of iron imparts a green color to the glass.

The Tariff Act of June 21, 1930, placed a duty on sand, containing 95 per cent or more of *Silica* and not more than six-tenths of 1 per cent of oxide of iron and suitable for use in the manufacture of glass, of $2 per ton.

SLATE.

Slate was first produced in California in 1889. Up to and including 1910 such production was continuous, but since then it has been irregular. Large deposits of excellent quality are known in the State, especially in El Dorado, Calaveras, and Mariposa counties, but the demand has been light owing principally to competition of cheaper roofing materials.

The production of slate in California during 1938 amounted to 6831 short tons having a total value of $30,281 f.o.b. quarry and came from properties in Calaveras, Inyo, and Tuolumne counties.

The 1938 figures showed a decrease in value as compared with those of 1937 which were 5036 tons and 440 squares having a total value of $32,572. Practically all the slate was crushed and used for roofing granules; and a small amount from Inyo County was sold as flagstone.

SOAPSTONE AND TALC.

The total output of talc and soapstone in California during 1938 amounted to 28,346 short tons valued at $290,810. This was a decrease in both quantity and value from the 1937 figures, which were 29,657 tons valued at $347,772. Of the 1938 production, 26,811 tons were high-grade talc from Inyo and San Bernardino counties, which material was utilized mainly in toilet powders, paint, paper, for rubber manufacture, and some in ceramics. The remainder of 1535 tons was soapstone and came from Butte, El Dorado, and Los Angeles counties.

The 'soapstone' grades were used mainly for ceramics and as a filler in roofing paper, part also in magnesite cement and foundry facing.

It is reported that California talc has replaced to some extent imported talc in the toilet trade on the basis of quality. The largest production of talc in the United States comes from Vermont and New York and of massive soapstone from Virginia.

During 1938 imports of talc steatite, etc., totaled 22,127 short tons valued at $391,198, as compared with 26,876 tons worth $472,819

during 1937, according to the United States Bureau of Foreign and Domestic Commerce.

The Tariff Act of 1930 places a duty on talc, steatite or soapstone and French chalk, crude or unground, of one-fourth of one cent per pound.

SODA.

The production of sodium salts in California in 1938 included: Soda ash, trona, caustic soda, and bicarbonates from plants at Owens Lake, Inyo County; and soda ash, salt cake, and trona (sesqui-carbonate, a double salt of Na_2CO_3 and $NaHCO_3$) from Searles Lake, San Bernardino County. There were no shipments of salt cake (sulphate) from Carrizo Plains, San Luis Obispo County.

The output for 1938 amounted to 178,105 tons valued at $2,023,610, as compared with 153,105 tons worth $1,461,057 in 1937.

The dense ash and bicarbonate were used mainly in the manufacture of soap, glass, paper, oil refining, sugar refining, and chemicals; and the trona for metallurgical purposes.

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America, and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development in California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibition purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20918 MANGANESE ORE. From Sonoma County, California, near Casadero—property of the Ore Metal and Engineering Corp.
Donor: Julius Messer, March, 1939.

20919 QUARTZ Crystal. From Springville, Tulare County, California.
Donor: Estate of Mrs. Emily Eldridge. April, 1939.

20920 ACTINOLITE. From Springville, Tulare County, California.
Donor: Estate of Mrs. Emily Eldridge. April, 1939.

20921 BARITE, $BaSO_4$, barium sulphate. From Santa Lucia Mountains, San Luis Obispo County, California.
Donor: Alexander Egenes. April, 1939.

20922 MERWINITE (microscopic) $Ca_3Mg(SiO_4)_2$, a calcium magnesium silicate associated with quartz, calcite, garnet, idocrase, and gehlenite. From Crestmore, Riverside County, California. Donor: Walter W. Bradley. April, 1939.

20923 GEHLENITE (microscopic) $Ca_2Al_2SiO_7$, a calcium aluminum silicate associated with quartz, calcite, garnet, idocrase, and merwinite.
From Crestmore, Riverside County, California.
Donor: Walter W. Bradley. April, 1939.

20924 ZIRCON SANDS, 98.5+% zircon, 66.5% ZrO_2. From Kaufield Dredge, Lincoln, Placer County, California.
Donor: M. M. Butler. April, 1939.

20925 IDOCRASE, calcium-aluminum silicate, in well-formed crystals.
From about five miles from Portola in southeastern Plumas County, California.
Donor: Benj. L. Handley. April, 1939.

LABORATORY

George L. Gary, Acting Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one, "Minerals of California," by Adolph Pabst, was published in 1938 by the Division of Mines as Bulletin 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

14. Lazulite, a basic aluminum iron and magnesium phosphate occurs as bands in garnetiferous quartzite from Alpine County.
15. Spessarite, a manganese—aluminum garnet from Riverside Co.
16. Melanterite, a hydrous ferrous sulphate occurring in small green and white fibrous crystals, from 6 miles south of Escondido, San Diego County.
17. Samarskite (niobate and tatalate of iron, calcium, uranium oxide, etc.) a velvet-black patent leather looking mineral was found associated with xenotime, monazite, tourmaline, orthoclase and garnet in the Southern Pacific silica quarry, ½ mile southeast of Nuevo, Riverside County.
18. Bulletin No. 113, page No. 104, Stibiconite, Kern County. Stibconite should be stibiconite.
19. Native copper in serpentine was found 6 miles west of Monticello, in Napa County.
20. Iddingsite a hydrous magnesium and iron silicate associated with green and red olivine has been found between Amboy and Bagdad, San Bernardino County, Calif.
21. Stibiconite, a hydrous antimony oxide occurs in the Old Woman Mountains, 12 miles south of Essex, San Bernardino County.
22. Olivine, a magnesium and iron silicate was found in an altered basaltic rock 3 miles east of Ravendale, Lassen County.
23. Bulletin 113, page 233, Analcime, Inyo County, andasitic should be andesitic.
24. Idocrase, a brownish-green calcium aluminum silicate occurs in tetragonal crystals, 5 miles from Portola, in southwestern Plumas County.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

LIBRARY

John C. O'Brien, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, California Journal of Mines and Geology contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the state are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:
- Topographic Maps:
  - Halls Flat Quadrangle.
  - Sonora Quadrangle.

U. S. Bureau of Mines:
- Report of Investigation:
  - 3437 Progress Reports—Metallurgical Division 31.
    Ore Dressing Studies. Flotation of Southern Illinois Lead-Zinc-fluorspar ores.
  - 3438 Progress Reports—Metallurgical Division 30.
    Electrometallurgical Investigations.
    Recovery of Potassium sulphur and alumina from alunite by fusion with boric acid.
- Information Circulars:
  - 7058 Mining and Milling Methods and Costs at the Alice Unit of the American Smelting & Refining Co., Alice, Colorado.
  - 7059 Safety at the Baton Rouge Refinery, Standard Oil Co. of Louisiana.

7060 Some phases of haulage accident prevention in anthracite mines.
7061 Accident Prevention at a Copper Smelter.

Books

Descriptive List of the New Minerals 1892-1938 English.

Union List of Serials of the San Francisco Bay Region compiled by Special Libraries Association.

National Research Council, Division of Geology and Geography. Annual Report for 1936-1937.

Report of the Committee on Sedimentation 1937-1938. National Research Council. Liparoceratid Ammonites, L. F. Spath.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.

Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers. New York
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Academy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.

California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Conservationist, Sacramento, California.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mining World, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining Press, Reno, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer Review, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colfax Record, Colfax, California.
Colusa Sun-Herald, Colusa, California.
Daily Commercial News, San Francisco, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Feather River Bulletin, Quincy, California.
Inland Oil Index, Casper, Wyoming.
Inyo Independent, Independence, California.

Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mohave Miner, Kingman, Arizona.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
New Equipment Digest, Cleveland, Ohio.
Oroville Mercury Register, Oroville, California.
Oil Marketer, Bayonne, New Jersey.
Placer Herald, Auburn, California.
Placerville Times, Placerville, California.
Plumas Independent, Quincy, California.
Randsburg Times, Randsburg, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.
Yreka Journal, Yreka, California.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

Write for latest revised price list.

REPORTS

Asterisks (**) indicate the publication is out of print.	Price Postpaid
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	$0.75
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	.75
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps William Irelan, Jr.	1.50
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D. NORDENHOLT, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

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QUARTERLY CHAPTER
OF
STATE MINERALOGIST'S REPORT XXXV

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

76807

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PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).
2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).
3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919-1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

Chas. Volney Averill, Mining Engineer

There is no report from the Redding Field District on account of unfinished field work.

SACRAMENTO FIELD DISTRICT

C. A. Logan, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. Laizure, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field Division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

W. B. Tucker and R. J. Sampson, Mining Engineers

On account of unfinished field work, there is no report from the Los Angeles Field District in this issue.

GEOLOGIC BRANCH

CURRENT NOTES

By OLAF P. JENKINS, Chief Geologist

In This Issue

There are still large areas in California, underlain by sedimentary rocks, which have long remained but little known as regards their geology. In this issue of the CALIFORNIA JOURNAL OF MINES AND GEOLOGY two of these areas are described by geologists who have made careful investigations of the regions. The Tertiary of the northern Sacramento Valley is described by Dr. C. A. Anderson and Dr. R. Dana Russell. The region of the Cuyama Valley, Caliente Range, and Carrizo Plain is described by Mr. J. E. Eaton. Both of these reports have required several years of field study and mapping and both are contributions to the program of work by the Geologic Branch. They should be of particular interest to those engaged in exploration for oil and gas.

A large part of the northern Sacramento Valley is covered by late Tertiary and Pleistocene sediments which contain much volcanic detrital material. These beds are mapped, described, and their origins are discussed. Beneath these beds lie an extremely thick series of shales, sandstones, and conglomerates of marine origin and belonging to the Cretaceous and Jurassic ages (upper Mesozoic). Also, in places, a series of marine and land-laid beds of clays, shales, and sandstones of Eocene age lie between the Cretaceous and the later Tertiary. These older rocks contain, in places, gas deposits and occasionally a small amount of oil. Though oil and gas is not the subject of the authors, the Geologic Branch has included on the accompanying map the location of wells drilled in the area by oil and gas companies, and a list of wells is printed on the back of the map with notations of the geologic formations in the bottom of the holes wherever it has been recorded.

Anyone who has driven through the Carrizo Plain or along the Cuyama Valley in the southern end of the Coast Ranges between Santa Maria and the southern end of the San Joaquin Valley could not but have become amazed at the vast area and thickness of sediments in this desolate region. Mr. J. E. Eaton has in this issue described and mapped in a very comprehensive manner this little-known part of California, correlating it with other parts of the state and showing what exploration has been made in it for oil and gas deposits.

As a supplement to the Division's Bulletins 104 and 115 which carry the Bibliography of the Geology and Mineral Resources of California through 1936, this July 1939 issue of the JOURNAL includes an extension of the bibliographic work to cover 1937. It has been done, as before, under the supervision of Dr. Solon Shedd. Most of the clerical work, however, should be accredited to Miss Corinne Kibler, and the financial support to the Works Progress Administration.

An interesting article, "The Giant Goose Lake Meteorite from Modoc County, California," by Dr. Earle G. Linsley, is also contributed to this issue of the JOURNAL through the courtesy of the California Academy of Sciences, before which society Dr. Linsley's paper was presented. The giant meteorite has been on display at the Golden Gate International Exposition in the Hall of Science of the University of California.

In the Next Issue

The October issue of the JOURNAL will be devoted largely to a state-wide investigation by Alfred L. Ransome and John L. Kellogg of the quicksilver resources of California. Accompanying the report, but distributed separately and prior to it, is the first of a series of state-wide economic mineral maps of California, No. 1. QUICKSILVER. The base of this map is the same (though reduced in size) as that of the Geologic Map of California and includes also the geologic boundaries and symbols of the formations. On it, printed in red, are the locations of all the known quicksilver deposits of the state—consistent producers, sporadic producers, and also mere claims which have not yet reached the producing stage. A lot of information is given in the margin of the map, in the form of descriptions and charts—geology and economics, mineralogy, uses, production, both world-wide and among the mines themselves, a list of the principal properties, and many other facts of interest and value. This map is particularly timely, since quicksilver is one of California's most strategic mineral products—of particular importance in time of war.

TERTIARY FORMATIONS OF NORTHERN SACRAMENTO VALLEY, CALIFORNIA

By Charles A. Anderson* and R. Dana Russell**

OUTLINE OF REPORT

ABSTRACT

Sediments and pyroclastic rocks of Tertiary age of the northern Sacramento Valley and adjacent areas to the north are discussed in this report. Though sediments of Cretaceous age are discussed in general, no attempt has been made to describe them in detail.

*Associate Professor of Geology, University of California.
**Associate Professor of Geology, Louisiana State University.

Several areas of Eocene (lower Tertiary) rocks are found in the northern Sacramento Valley. In the Rumsey Hills, Marysville Buttes and Oroville Table Mountain, fossiliferous sandstones, shales and local conglomerates indicate a marine embayment in this region during middle Eocene time.

The Ione formation is limited to the foothills of the Sierra Nevada and represents a deltaic deposit of middle Eocene age. Also during the same epoch, a basin to the east of the northern end of the present Sacramento Valley was filled by continental deposits (Montgomery Creek formation). The gravels, sands, shales, and coal seams of this formation represent fluviatile, lake, and swamp conditions. Sixty miles to the west a somewhat similar formation (Weaverville beds) may possibly be of the same age, although the available evidence indicates it is younger (lower Oligocene).

Along the western border of the Sierra Nevada, rhyolite tuff of uncertain age overlies the Ione formation. This rhyolite tuff is covered in many places by andesitic tuffs and breccias of upper Miocene to lower Pliocene in age. Southeast of Marysville, similar appearing andesitic rocks underlie rhyolite tuffs, and have been proved to be of upper Eocene to lower Oligocene in age. Upper Miocene or lower Pliocene rhyolitic and andesitic sediments are exposed around the Marysville Buttes.

The greatest accumulation of sediments and pyroclastics took place during upper Pliocene when floodplain deposits filled a downsinking valley floor forming a broad alluvial valley similar to, but considerably larger than, the present alluvial valley of the Sacramento. These deposits, the Tehama formation, consist of silts, sands, and gravels derived from the Coast Range to the west. They attain a thickness of more than 2000 feet in the central portion of the Pliocene valley. At the time of their deposition, volcanoes to the east were contributing basaltic and andesitic material for the mudflows of the Tuscan formation. These were deposited at the same time as the Tehama formation of the west, interfingering with its beds in the center of the valley. At the northern end of this Pliocene valley, both non-volcanic and volcanic gravels and sands accumulated together (Tuscan-Tehama sediments). Early in the accumulation of these upper Pliocene rocks, a widespread dacite tuff (Nomlaki tuff) blanketed the northern portion of the valley, covering the previously deposited Tehama and Tuscan formations. The Nomlaki tuff, in turn, was covered by more sediments and mudflows of the Tehama and Tuscan formations. The Nomlaki tuff, therefore, serves as a valuable horizon marker within this series of beds. Both the Tehama and Tuscan formations were covered in part by a thin mantle of Pleistocene Red Bluff gravels and sands. An unconformity (or disconformity) separates the Red Bluff gravels from the underlying formations.

High grade clays are found in the Eocene Ione formation. Coal is present in the Eocene Montgomery Creek formation. The Nomlaki tuff has been used for building stone. Natural gas has been developed from the Cretaceous rocks but so far none has been obtained from the Tertiary sediments in the northern Sacramento Valley*.

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* Farther to the south, however, there is a producing gas field—the Rio Vista—which obtains gas from sands of the Eocene.—(*O. P. J.*)

INTRODUCTION

Although the Tertiary formations of the central and southern Coast Ranges of California have received much attention from geologists, paleontologists, and stratigraphers, largely because of the marine character of the rocks and their close association with oil, the Tertiary stratigraphy of northern California has been neglected. Very little has been done since the pioneer work of Diller near the end of the last century. The paucity of Tertiary marine sediments and the apparent lack of oil-bearing strata no doubt account for this neglect.

In view of the limited amount of literature on the Tertiary formations of the northern Sacramento Valley region, and in view of the fact that many of the older publications are out of date, the California State Division of Mines has deemed it advisable to assemble the available data, including the results of more recent investigations. During 1929 and 1930, R. Dana Russell studied two Tertiary formations in detail: the Montgomery Creek formation (Eocene), and the Tehama formation (Pliocene) of the northern Sacramento Valley region; in connection with this work, other Tertiary formations were briefly investigated. At the same time Charles A. Anderson studied the Tuscan formation (Pliocene), which interfingers with the Tehama formation. Except for the preparation of a preliminary draft of this paper, Mr. Russell has been unable to present his data for publication, owing to the pressure of other duties. Since Mr. Anderson is familiar with the problems, having worked with Russell in the study of critical areas, he has prepared the paper for publication, revising Russell's draft, and drawing in part from Russell's thesis [1], which is filed in the University of California Library. Both writers have checked and revised the final manuscript.

The present paper summarizes the results of Russell's work, and includes unpublished material generously contributed by others. Considerable emphasis has been placed upon the widespread and important Tehama formation, since little information has previously been published concerning it.

Mr. Russell is responsible for the mapping of the Tehama formation, the Nomlaki tuff, and the area north of 41 degrees latitude and east of 122° longitude on the accompanying geological map (see fig. 1 and accompanying map). The remaining geology, compiled from the following sources, has been modified, particularly in the areas where the Tuscan formation appears, by Mr. Anderson:

1. Diller, J. S. Redding folio, no. 138: U. S. Geological Survey.
2. Diller, J. S. Lassen Peak folio, no. 15: U. S. Geological Survey.
3. Reconnaissance soil survey of the Sacramento Valley: U. S. Dept. of Agriculture, Bureau of Soils, advance sheets, field operations, 1913.
4. Soil survey of the Redding area: U. S. Dept. of Agriculture, Bureau of Soils, advance sheets, field operations, 1907.

[1] Russell, R. D., The Tehama formation of northern California: Thesis for Ph. D. Library Univ. Calif.

5. Taff, J. A. (Associated Oil Co.). Geologic map of the Sacramento Valley area (unpublished).

6. Young, George S. Geologic map of the northern portion of the Rumsey Hills area (unpublished).

7. Williams, Howel. Geologic map of the Marysville Buttes: Univ. Cal. Publ. Bull. Dept. Geol. Sci., vol. 18, no. 2, 1929.

Contacts have been generalized in keeping with the scale of the map. They are, however, believed to be comparatively accurate in the area mapped by Russell, in the Redding quadrangle, and in the region of the Marysville Buttes. East of the Sacramento River, in the Redding quadrangle, the Pliocene lying above the Nomlaki tuff is mapped as Tuscan, although mixed Tuscan-Tehama sediments are interbedded with Tuscan tuff breccias. The other contacts are approximate, their accuracy varying according to the source of information. It is possible that the Montgomery Creek formation does not cover

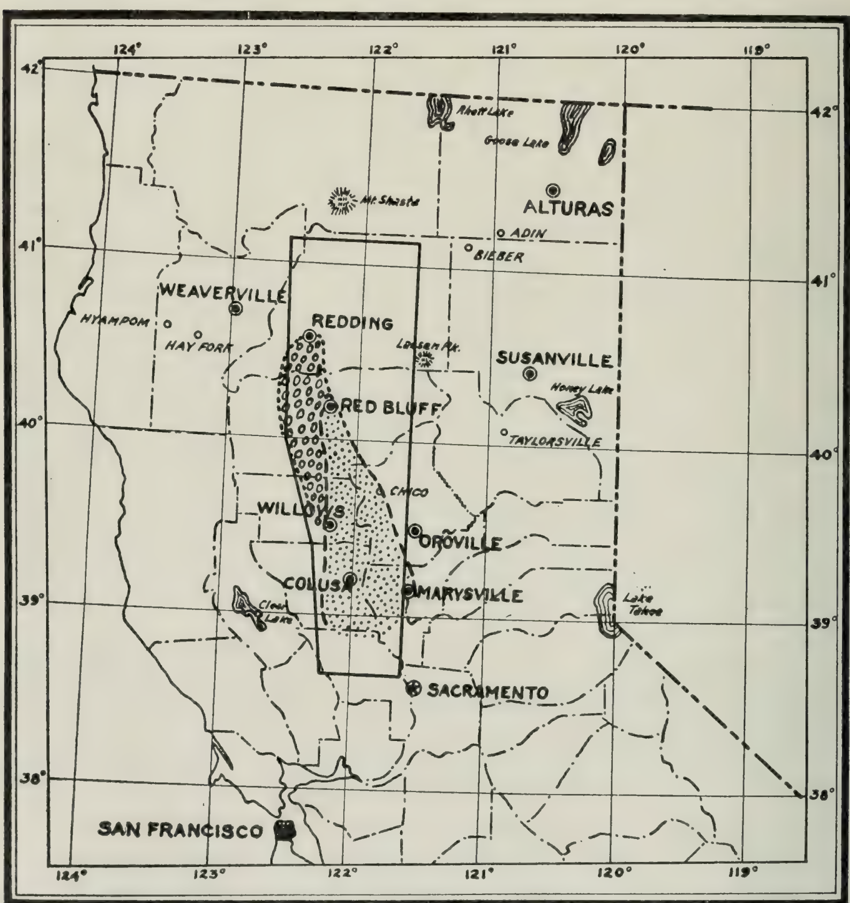

FIG. 1. Index map of northern California showing: (outlined area) location of accompanying geologic map; (dotted area) boundary of the alluviated portion of the *present* northern Sacramento Valley (dashed line); (circled-dot area) the approximate boundary of the alluviated portion of the *upper Pliocene* northern Sacramento Valley.

an area as large as shown on the map, and it is certain that patches of basalt overlying the Tuscan formation on the east side of the Sacramento Valley are more numerous than indicated.

Unfortunately, data are insufficient for separating the Red Bluff formation and other Pleistocene gravels. These deposits occur as patches unconformably overlying the Tertiary and Cretaceous formations, and, in limited areas, the basement complex.

The reconnaissance nature of the mapping and the meager data available have made it inadvisable to attempt to show structural relationships of the formations. Discussion of structure is, therefore, limited to brief statements included with descriptions of formations.

Acknowledgments

For financial assistance in his investigation, Mr. Russell is especially indebted to the Board of Research of the University of California, and to Professor N. E. A. Hinds; Professor Hinds has also generously contributed advice and field data. The many services of Mr. S. D. Furber of Corning, and the services of Mr. A. W. Vitt as field assistant during the summer of 1930 are gratefully acknowledged. Messrs P. B. Cross, Charles S. Magill, G. J. Sielaff, J. A. Taff, Louis Chasseur, George S. Young, and others have contributed much information. Both writers have profited from conferences with Professors Howel Williams and Charles E. Weaver. Fossil leaves collected from the Montgomery Creek formation were determined by Professor Ralph W. Chaney.

PRE-TERTIARY ROCKS

Only a brief description is given of the pre-Tertiary rocks surrounding the upper portion of the Sacramento Valley. In the Coast Ranges, Klamath Mountains, and Sierra Nevada (fig. 2), these rocks are of distinctive and recognizable types, and, when found as pebbles in the later formations, afford evidence of the sources of these formations.

Coast Ranges

The eastern portion of the northern Coast Range province is composed of sediments and lavas of the Franciscan series together with intrusive igneous rocks, all presumably of Jurassic age. The intrusive rocks are dominantly serpentines derived from pyroxenites and peridotites. Though very little is known of the character of the Franciscan series in this particular region, sandstones, shales, radiolarian cherts, interbedded volcanics, and the metamorphic derivatives of these rocks may be expected to occur as in other areas where the series has been more carefully studied. The Franciscan metamorphic rocks are rather characteristic: glaucophane schist, actinolite schist, and schists composed of quartz, albite, and muscovite.

Klamath Mountains

A great series of metamorphosed sediments, tuffaceous sediments, and igneous rocks, ranging in age from pre-Devonian to Jurassic, have been mapped in the Redding[2] and Weaverville[3] quadrangles. The major structure is homoclinal; the older beds (schists) occur on the west, with younger formations appearing successively to the east. Plutonic and hypabyssal intrusives, probably of two distinct ages, the first Paleozoic[4] and the second late Jurassic,[5] cut the older rocks. Serpentine is also present; its exact age is not known, but it is pre-Cretaceous and post-Mississippian.

Sierra Nevada

Diller[6] has mapped and briefly described a series of somewhat metamorphosed sediments and associated volcanics ranging in age from Silurian to upper Jurassic, which occur in the vicinity of Taylorsville (fig. 1), at the northern end of the Sierra Nevada. These rocks have been intruded by serpentine, quartz diorite, granodiorite, and associated dike rocks of late Jurassic age.

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[2] Diller, J. S. Redding folio, no. 138: U. S. Geol. Survey, 1906.
[3] Hinds, N. E. A. Geologic formations of the Redding-Weaverville districts, northern California: Cal. State Div. of Mines, Rept. 29, pp. 77-122, 1933.
[4] Hinds, N. E. A. Paleozoic eruptive rocks of the southern Klamath Mountains, California: Univ. Cal. Publ. Bull. Dept. Geol. Sci., vol. 20, pp. 406-407, 1932.
[5] Hinds, N. E. A. Mesozoic and Cenozoic eruptive rocks of the southern Klamath Mountains, California: Univ. Cal. Bull. Dept. Geol. Sci., vol. 23, pp. 331-361, 1935.
[6] Diller, J. S. Geology of the Taylorsville region, California: U. S. Geol. Survey, Bull. 353, 1908.

Fig. 2. Physiographic subdivisions of central and northern California. *Photo of relief map by courtesy of H. A. Sedelmeyer, Berkeley, California.*

Knoxville-Shasta-Chico Sedimentary Series

The thick series of Mesozoic beds on the eastern border of the northern California Coast Ranges, between the basement complex (Franciscan and pre-Franciscan), and the Tertiary sediments, has been the subject of numerous studies. This Mesozoic series was thought by Diller and Stanton[7] to be a conformable sequence of Cre-

[7] Diller, J. S., and Stanton, T. W. The Shasta-Chico series: Bull. Geol. Soc. Amer., vol., 5, pp. 435-464, 1894.

taceous age; but since that time, the work of F. M. Anderson[8] and others has shown it to consist of three series: the lowest (Knoxville), of upper Jurassic age; the middle (Shasta), of lower Cretaceous age; and the upper (Chico), of upper Cretaceous age. The section measured by Diller and Stanton on Elder Creek indicated that the total sequence had the enormous thickness of 30,000 feet. They assigned 20,000 feet to the Knoxville, 6,000 to the Horsetown (Shasta), and 4,000 feet to the Chico. F. M. Anderson's work, however, has shown that the upper 3,000 feet of the Knoxville exposed on Elder Creek should be assigned to the Shasta, since it is of Cretaceous age; he has named this series of strata the Paskenta. The lower 14,000 feet he believes to be of upper Jurassic age. The present classification of the beds, according to F. M. Anderson[9] is as follows:

	Age	*Approx. Thickness*
1. Chico series	Upper Cretaceous	4,000— 7,500 ft.
2. Shasta series	Lower Cretaceous	12,000—20,000 ft.
A. Horsetown beds		
B. Paskenta beds		
3. Knoxville series	Upper Jurassic	14,000 ft.

In the northern Sacramento Valley region, the Knoxville and Shasta series consist predominantly of dark gray carbonaceous shale with subordinate amounts of sandstone, conglomerate, and impure limestone. Nodular weathering of the shale is striking and characteristic. The lower part of the Chico series is similar in lithology to the Knoxville and Shasta, but contains more sandstone. The upper Chico is composed chiefly of sandstone with numerous conglomerate beds and minor amounts of shale. The Knoxville and Shasta series are exposed only to the west of the Sacramento River; the Chico series also occurs east of the river in the Redding and Lassen Peak quadrangles and along the western border of the Sierra Nevada farther south. In these areas, wherever the base of the Chico is exposed, the formation lies unconformably upon rocks of the basement complex.

Recently F. M. Anderson[10] published a memoir dealing with the lower Cretaceous rocks of California and Oregon. Many pertinent details concerning the distribution and thickness of the beds can be found therein.

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[8] Anderson, F. M. Knoxville-Shasta succession in California: Bull. Geol. Soc. Amer., vol. 44, p. 1237-1270, 1933. (Contains bibliography of earlier reports.)

[9] Anderson, F. M. *Op. cit.*, p. 1269. Anderson, F. M. Chico series in California and Oregon: Bull. Geol. Soc. Amer., vol. 49, no. 12, pt. 2, p. 1863, 1938.

[10] Anderson, F. M. Lower Cretaceous deposits in California and Oregon: Geol. Soc. Amer., Special Paper 16, 1938.

TERTIARY FORMATIONS

The Tertiary formations will be discussed under general locality headings, since the sections differ and exact correlations have not been made.

Northern Sacramento Valley and Southwestern Edge of Cascade Range

The Tertiary rocks of this region have been divided into the Montgomery Creek formation (Eocene), the Tehama and Tuscan formations (Pliocene), and volcanics, the exact age of which is not known.

Previous Literature

For much of our information concerning the above region we are indebted to J. S. Diller. In 1887[11] he first described the Tuscan formation and a series of sediments in the Lassen Peak region (here termed the Montgomery Creek formation) which lie between the Tuscan and the Chico formations. Diller assigned these older sediments to the Miocene on the basis of Knowlton's determinations of fossil leaves; the Tuscan formation was assigned to the Pliocene. No formational name, however, was given to either formation.

In 1892 Lindgren[12] submitted the text of the Sacramento folio in which he described and named the Ione formation. In Diller's next publication,[13] he stated that the ''Miocene'' sediments in the Lassen region were the equivalent of the Ione formation and designated them by that name; at the same time he applied the term ''Tuscan tuff'' to the series of volcanic breccias and tuffs overlying the ''Ione''. In 1893[14] he included in the Tuscan the dacitic tuff (now known as the Nomlaki tuff) on the west side of the Sacramento Valley and again correlated with the Ione formation the beds which lie beneath the tuff. Ransome,[15] however, in 1896, stated that this correlation with the Ione was ''little more than a guess.''

After an exhaustive study of the Ione formation, Allen[16] has suggested that it be restricted to the beds along the foothills of the Sierra Nevada that are composed of anauxite (hydrous aluminum silicate), quartz, and a group of other minerals resistant to intensive chemical decay. Tuffs and tuffaceous clays overlie the non-volcanic material of the Ione formation. Allen[17] visited some of the localities in Tehama County described as Ione by Diller, and found that the fine sediments beneath the Nomlaki tuff are partly tuffaceous in contrast to the type Ione. Furthermore, Allen[18] found that the northern limit of recog-

[11] Diller, J. S., Geology of the Lassen Peak district: U. S. Geol. Survey, 8th Ann. Rept., pt. 1, p. 413 *et seq.*, 1887.
[12] Lindgren, W., Sacramento folio no. 5: U. S. Geol. Survey. 1894.
[13] Diller, J. S., Lassen folio no. 15, prelim. ed.: U. S. Geol. Survey, 1892.
[14] Diller, J. S., Tertiary revolution in the topography of the Pacific Coast: U. S. Geol. Survey, 14th Ann. Rept., pt. 2, pp. 411-416, 1893.
[15] Ransome, F. L., The Great Valley of California: Univ. Cal. Pub. Bull. Dept. Geol., vol. 1, p. 377, 1896.
[16] Allen, V. T., The Ione Formation of California: Univ. Cal. Publ. Bull. Dept. Geol. Sci., vol. 18, pp. 353-354, 1929.
[17] *Op. cit.*, pp. 414-415.
[18] *Op. cit.*, p. 373.

nizable, typical Ione is at Table Mountain, north of Oroville (fig. 1). Allen[19] suggested that the Ione formation accumulated largely as deltaic deposits in a sea which occupied what is now the Great Valley of California during middle Eocene time (Capay stage).[20]

Neither Diller nor Allen refer to the beds immediately above the Nomlaki tuff. These beds are identical with those below the tuff, and are of greater thickness. Diller's sections[21] show the tuff to be overlain directly by a considerable thickness of the Pleistocene Red Bluff formation, hence he apparently considered that all the sediments above the tuff belonged to this formation. Bryan[22] seems to have drawn the same conclusion, as he designates all beds above the ''Tuscan tuff'' as ''older alluvium.'' Hershey,[23] however, apparently recognized that more than one formation was represented, but he gave little description of the rocks.

In an earlier publication, Russell[24] indicated that the Red Bluff formation is comparatively thin, and that about 2,000 feet of conformable beds lie with unconformable relationships between the Pleistocene Red Bluff and the Cretaceous Chico formations. This series of sediments was very briefly described, and named the Tehama formation. The ''Tuscan tuff'' on the west side of the Sacramento Valley was considered a member of the Tehama formation, and because of its distinctive appearance and value as a horizon marker, it was given a separate name, the Nomlaki tuff. A vertebrate fauna contained in the Tehama beds above the Nomlaki was determined by Vander Hoof as upper Pliocene. Evidence was cited to prove that the Tehama and Tuscan are contemporaneous. Later, C. A. Anderson[25] discussed the character and distribution of the Tuscan formation.

Montgomery Creek Formation

The Montgomery Creek formation consists of a series of sandstones, conglomerates, and shales, with interbedded coal seams, outcropping at the southwestern edge of the Cascade Range. The most northerly outcrop of the Montgomery Creek so far discovered occurs near the head of Kosk Creek (see accompanying map); the most southerly is on the ridge north of Battle Creek near the southern edge of Shasta County. The ''Ione'' sediments occurring farther south at Tuscan Springs, Mill Creek, Deer Creek, and Chico Creek[26] are largely non-volcanic gravels and sands lying below the Tuscan formation. Little can be stated concerning their age, except that they are pre-Tuscan and post-Cretaceous, and have none of the characteristics of the middle Eocene Ione formation.

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[19] *Op. cit,* pp. 402-404.

[20] Clark, B. L., and Vokes, H. E. Summary of marine Eocene sequence of western North America: Bull. Geol. Soc. Amer., vol. 47, p. 856, 1936.

[21] Diller, J. S., Tertiary revolution in the topography of the Pacific Coast: U. S. Geol. Survey, 14th Ann. Rept., pl. 44, opp. p. 412, 1893.

[22] Bryan, Kirk, Geology and groundwater resources of Sacramento Valley, California: U. S. Geol. Survey Water Supply Paper 495, p. 74, 1923.

[23] Hershey, O. H. The Quaternary of southern California: Univ. Cal. Publ. Bull. Dept. of Geol. Sci., vol. 3, p. 11, 1902.

[24] Russell, R. D., and Vander Hoof, V. L. A vertebrate fauna from a new Pliocene formation in northern California: Univ. Cal. Pub. Bull. Dept. Geol. Sci., vol. 20, pp. 11-21, 1931.

[25] Anderson, C. A., The Tuscan formation of northern California with a discussion concerning the origin of volcanic breccias: Univ. Cal. Publ. Bull. Dept. Geol. Sci., vol. 23, pp. 215-276, 1933.

[26] Diller, J. S. Tertiary revolution in the topography of the Pacific coast; U. S. Geol. Survey, 14th Ann. Rept., pt. 2, p. 417, 1893.

The Montgomery Creek formation apparently overlies the Chico formation unconformably. Russell was unable to find a well exposed contact between the two, but at its easternmost outcrops, the dip of the Chico is at low angles to the west and southwest, while the overlying Montgomery Creek formation dips three to five degrees to the east. Later volcanics unconformably overlie the Montgomery Creek formation.

The thickest section of the Montgomery Creek formation found by Russell occurs on Montgomery Creek $2\frac{1}{2}$ miles northeast of the village of the same name. At this locality the base is not exposed, but more than 600 feet of beds outcrop on the steep ridge on the north side of the creek. Diller[27] reports that the Montgomery Creek formation attains a thickness of over 1,000 feet near the head of Kosk Creek; Russell's observations at that locality, however, led to the conclusion

FIG. 3. Sandstones and conglomerates of the Montgomery Creek formation (Eocene); north side of Montgomery Creek, the type locality, two and a half miles east-northeast of the village of the same name. Note the 'cannonball' concretions. Looking north.

[27] Diller, J. S., Redding folio no. 138: U. S. Geol. Survey, 1906.

that the thickness there was much less—not more than 300 feet. It is quite possible that the formation attains a thickness of 1,000 feet elsewhere, since all of the localities were not visited because much of the region is accessible only by pack train.

The sediments of the Montgomery Creek formation are gray-green in color and weather to a yellowish or reddish brown. Many samples are often highly micaceous and most are arkosic, though light-colored quartz sands are locally present. The quartz sands are somewhat similar to the white quartz sands of the Ione formation, though no anauxite has been found in them; with the exception of these sediments the Montgomery Creek formation is entirely distinct in lithology from the Ione. The lithology is much more like that of the Chico formation, as both are arkosic and contain large red-brown ''cannonball'' concretions (fig. 3); but the Montgomery Creek is less consolidated and not so well sorted.

Cross-bedding, sometimes on a gigantic scale, is common in the coarser beds of the Montgomery Creek formation, and in every case where the relationships are clear, the indications are that the streams which deposited the beds came from the east or northeast. That the source of the sediments was in this direction is also indicated by the pebbles present in the conglomerates. These consist of volcanic rocks distinct from the pre-Tertiary volcanics in the Redding quadrangle and similar to some of the later lavas; of meta-sediments which might be from either eastern or western rocks; and of meta-volcanics which are identical in petrographic character with certain types present in the Taylorsville area but absent in the region to the west.

The formation is chiefly a series of fluviatile and delta deposits. That lakes and swamps were also present at various times is indicated by the presence of coal beds and occasional freshwater shells. Distribution of outcrops indicates that the basin of deposition extended at least forty miles in a north-south direction and that it was limited on the west, near the present western margin of outcrop of the formation, by a ridge of older rocks, upon which the formation overlaps from the east. This ridge, though somewhat irregular in shape, had a general north-south trend and lay approximately along the present 122 degree longitude line. The extent of the formation to the east is unknown, as it is covered by later volcanics.

Fossil leaves were collected from several localities in the Montgomery Creek formation. They were examined by R. W. Chaney,[28] who pronounced them definitely of Eocene age.

The Weaverville formation,[29] a series of sediments downfaulted into the more resistant bedrock in the region around Weaverville (fig. 1), 30 to 40 miles west and northwest of Redding, may be correlative with the Montgomery Creek formation. The Weaverville formation consists largely of silts and sandy conglomerates, with irregular gradations from fine to coarser material in its upper portions. Also included in this formation are tuffs, diatomaceous shales, lignitic shales, and sub-bituminous coal or lignite. According to MacGinitie,[30] these rocks

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[28] Personal communication.

[29] Hinds, N. E. A., Geologic formations of the Redding-Weaverville districts, northern California: Cal. State Div. of Mines., Rept. 29, pp. 115-116, 1933.

[30] MacGinitie, H. D., The flora of the Wearverville beds of Trinity County, California: Carnegie Inst. Wash. Publ. 465, pp. 83-151, 1937.

apparently are products of both channel and flood-plain-lake deposition. A study of the associated fossil plants has led MacGinitie to suggest that the Weaverville formation is lower Oligocene in age, presumably younger than the Montgomery Creek. However, a rather abundant flora was found in the Weaverville formation, and further collections from the Montgomery Creek might indicate a closer correlation of the two.

Tuscan Formation

The Tuscan formation consists of a series of volcanic breccias, tuffs, volcanic gravels and sands, and tuffaceous clays. Its thickness ranges from a few feet to more than 1,000 feet. The greatest exposed thickness occurs along the eastern edge of the formation, where only breccias are found. It thins in the direction of the Sacramento Valley, where gravels, sands, silts and clays are interbedded with the breccias (fig. 4).

FIG. 4. Iron Canyon, Sacramento River, northeast of Red Bluff. Tuscan formation (upper Pliocene) with stratified volcanic gravels and sands; massive volcanic breccia at the top. Looking east.

The latter presumably are the products of mud flows, while the volcanic sediments represent breccias re-worked by streams. The formation outcrops on the eastern side of the Sacramento Valley and at the southwestern edge of the Cascade Range; it extends from Pentz, 13 miles southeast of Chico, Butte County, north to the vicinity of Round Mountain, Shasta County.

Since the outcrops converge and thicken to the east, the source of the Tuscan formation must have been old volcanoes in the vicinity of Lassen Peak or farther east. It should be emphasized that the present volcanoes contributed nothing to the Tuscan formation. The rocks of the Tuscan formation are largely andesitic and basaltic, the latter pre-

dominating, except in the region east of Redding, where the fragments are of dacitic and andesitic[31] lava.

The Tuscan is contemporaneous with the Tehama formation and interfingers with the latter in their zone of junction; both formations are upper Pliocene in age. The details of the evidence leading to these conclusions will be presented in the following section.

Tehama Formation

General Statement. The Tehama formation consists of silts, silty clays, sands, and gravels, predominantly pale yellowish to greenish-gray, weathering pale buff to yellow-brown. A prominent and distinctive tuff member, the Nomlaki tuff, occurs near the base. The Tehama attains a thickness of more than 2,000 feet in the central part of the Pliocene valley in which it accumulated, with the Nomlaki tuff member about 700 feet above the base. To the west, the thickness of the formation decreases as it overlaps on the Cretaceous beds, so that locally the Nomlaki, and in places the Tehama sediments above the Nomlaki, lie directly upon the Cretaceous. Many of the finer sediments, both above and below the Nomlaki tuff, are tuffaceous, and beds of fine-grained vitric tuff occur at several horizons. Exclusive of the Nomlaki tuff, however, the volcanic admixtures probably aggregate not more than ten per cent of the formation, except at the north end of the Sacramento Valley in the Redding quadrangle. Since the sandy and clayey silts which make up a major part of the Tehama formation are commonly massive and give unsatisfactory evidence of structure, the

FIG. 5. Tehama fine silty sands (upper Pliocene). Redbank Creek, Old Nomlaki Indian Reservation headquarters, Tehama County. Looking north.

[31] Anderson, C. A., The Tuscan formation of northern California with a discussion concerning the origin of volcanic breccias: Univ. Cal. Publ. Bull. Dept. Geol. Sci., vol. 23, pp. 224-229, 1933.

Nomlaki tuff member is of great importance in structural interpretation.

Distribution. The general distribution of the Tehama formation and of the Nomlaki tuff member is shown on the map (see accompanying geologic map). Unfortunately, time was not available for the differentiation of the Pleistocene Red Bluff gravels, so it must be remembered that patches of the Red Bluff cap the Tehama formation and overlap on the Cretaceous throughout much of the region. Near the eastern edge of the area mapped as Tehama, the Red Bluff is almost continuous, and outcrops of the Tehama occur only in the deeper stream cuts.

The Tehama formation overlaps the Cretaceous beds and is separated from them by an angular unconformity. The formation thickens rapidly toward the center of the Pliocene valley, whose central axis lay a little west of the present Sacramento River. (See cross-section, with accompanying geologic map.)

Character of the Sediments. The Tehama sediments in general, are poorly sorted. The most common and widespread type is massive, sandy silt (fig. 5), which toward the west grades into fine silty sands and toward the east into clayey silt. The coarser beds are often cross-bedded, with fore-set beds on the east (fig. 6), indicating that the streams which deposited them came from the west. In the more northerly outcrops, the cross-bedding and pebbles in the gravels indicate that streams flowed from the northwest and north.

That the Tehama is a series of fluviatile deposits is shown by the rather poor sorting of the sediments, the channels of coarser sediments in the finer textured strata, and the lenticular character of the coarser beds. Moreover, the predominance of fine beds, and their massive character and wide distribution, indicate that the sediments were deposited under flood plain conditions. Vertebrate remains present in the formation furnished further evidence supporting the same conclusion. Most of the bones are fragmentary, only the teeth and foot bones being well preserved, and these often are somewhat rounded by stream action. The bones are widely scattered, and occasionally show the effect of gnawing by rodents. The field evidence indicates that the sediments accumulated upon the western side of a broad valley, similar to the present Sacramento Valley but of greater extent.

The Tehama beds are usually uncemented and only poorly consolidated, though zones of nodules cemented with calcareous matter are locally present. At the present time the deposition of dissolved calcareous material from ground water at or near the surface is operating in the same region during the dry summer season. As the climate during the upper Pliocene closely resembled that of the present,[32] these nodular zones probably represent pauses in the progress of sedimentation such as are common on the flood plains of this area today.

The mineral composition of the Tehama sediments, and the pebbles present in the Tehama gravels, prove that the material composing the formation were derived from the Coast Ranges and Klamath Mountains to the west and northwest. East of the Sacramento River in the

[32] Dorf, Erling, Pliocene floras of California: Carnegie Inst. Wash. Publ. 412, p. 66, 1930.

Fig. 6. Cross-bedded Tehama gravels (upper Pliocene) fore-set beds dipping east. Dibble Creek, five miles west of the Southern Pacific Railroad, Tehama County. Looking south.

Redding quadrangle, the Pliocene sediments which occur below typical Tuscan volcanic breccias consist of material from the basement complex of the Klamath Mountains mixed with volcanic material of eastern sources. These sediments are neither true Tuscan nor Tehama; their mixed character is best indicated by the designation "Tuscan-Tehama sediments." They have been shown as Tuscan on the accompanying map.

Relationship to the Tuscan Formation. Evidence of the contemporaneity of the Tuscan and Tehama formations may be summarized as follows:

1. The Nomlaki tuff is interbedded with both formations. It is exposed near the base of the Tuscan at Tuscan Springs and farther south in the canyons of Antelope and Butte creeks. These outcrops are too small to be shown on the geologic map.

2. Along the Pacific Highway between Red Bluff and Cottonwood, fine gravels, sands, silts, and clays composed of andesitic and basaltic debris, outcrop in road and stream cuts. Traced to the east, these sedimentary tuffs and volcanic gravels are found intercalated with Tuscan breccias in the vicinity of Iron Canyon and Bend. To the west, they are replaced by non-volcanic sediments of western source (Tehama formation). Though outcrops are not continuous because of soil cover and because of the Red Bluff gravel capping, there can be no doubt concerning the interfingering of the two formations.

3. Core samples from the Johnson No. 1 well, Orland Oil Syndicate, give conclusive evidence that the two formations interfinger in

their zone of junction. Andesitic and basaltic debris from an eastern source is interbedded with sediments of western source.

As stated in a previous paper,[33] the differences in character and mode of deposition between the Tehama and the Tuscan formations seem sufficiently great to justify separate formational names in spite of the contemporaneity of the formations.

Relationship to the Red Bluff Formation. The Red Bluff formation overlies the Tehama, locally overlies the Tuscan, and also overlaps upon the Cretaceous. The Red Bluff is an alluvial deposit consisting largely of gravels with a minor amount of interbedded sands. The gravels consist of sub-angular to sub-rounded boulders, cobbles, and pebbles in a matrix of sandy clay which is commonly deep brick-red in color. Although both the Tehama and Red Bluff vary considerably in grain-size at any locality where both are exposed, the Red Bluff is usually much coarser; this feature together with the red color of the Red Bluff, serves to distinguish it easily from the underlying Tehama. Along the eastern border of the area mapped as Tehama, both formations are flat-lying and are separated by a disconformity, but farther west, especially along the western margin of the Tehama formation, they are separated by an angular unconformity. In the vicinity of Redding, the Red Bluff locally exceeds 100 feet in thickness, but south of the latitude of the town of Anderson numerous well-exposed sections show a thickness of less than 50 feet.

Structure. The general structure of the Tehama is homoclinal, with dips averaging about four degrees to the east along the western border of the formation, and decreasing to zero along its eastern margin. Considered together with the Tuscan formation, which interfingers with the Tehama along the central axis of the old valley, the general structure is a broad syncline. Between Deer Creek and Bend, six miles north-northeast of the town of Red Bluff, this simple structure is modified by a monocline in the Tuscan. Local anticlinal folds are present in the Tuscan at Tuscan Buttes (vicinity of Tuscan Springs) at Iron Canyon south of Bend, along the Pacific Highway north of Red Bluff, and in the hills east of Corning.

Age. The vertebrate fossils which determine the age of the Tuscan and Tehama formations were found 18 miles west-northwest of Corning, in Tehama silty clays. At one locality bone fragments were found 10 feet above the Nomlaki tuff, and since there is no stratigraphic break between the fossil beds and the tuff, the fossils determine the age of the tuff. Other fossils were collected several miles to the east in two horizons, 200 feet apart stratigraphically, the lower horizon occupying the same position stratigraphically as at the first locality. The faunas of both beds appear to be identical. In all, 10 different vertebrate genera have been found to date, and Vander Hoof[34] has concluded that they represent a true upper Pliocene fauna.

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[33] Russell and Vander Hoof, *op. cit.*, p. 15.
[34] Russell and Vander Hoof, *op. cit.*
Vander Hoof, V. L. Additions to the fauna of the Tehama upper Pliocene of northern California: Am. Jour. Sci., vol. 25, pp. 382-384, 1933.

Locality Descriptions of Tehama Formation

Stony Creek Buttes and Vicinity: Individual sections of the Tehama will be discussed in order of position from south to north, starting with Stony Creek Buttes, located 8 miles west of Orland. These three Buttes, capped by basalt, rise 200 to 300 feet above the surrounding country, and form a conspicuous landmark. The basalt cap is 20 to 30 feet thick, and dips about 5 degrees to the east. It is a black aphanitic rock with well developed columnar jointing.

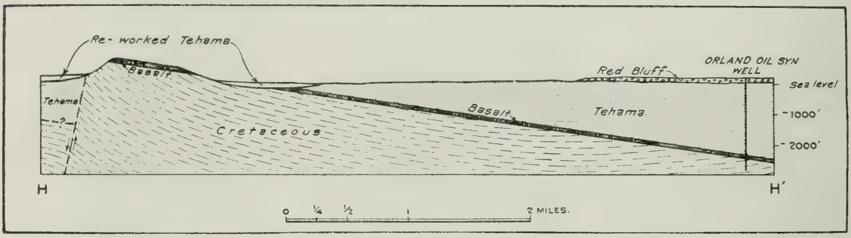

FIG. 7. Generalized cross-section through Middle Butte of the Stony Creek Buttes and the Orland Oil Syndicate well.

Sandy silts, sands, and gravels of the Tehama formation surround the buttes except near the lava, where Cretaceous sandstones and shales outcrop.

Three miles east of North Butte, the Johnson No. 1 Well of the Orland Oil Syndicate drilled through the following formations:

Red Bluff: There is some doubt as to the thickness of this formation, as no cores were taken in the upper 405 feet of the well, though gravels were reported to that depth. Two miles west of the well only a thin capping of the Red Bluff is found, but it may be that the formation reaches a thickness of 100 feet or more at the well, particularly if a channel was penetrated.

Tehama: Cores from the Orland Syndicate well give important information concerning the Tehama formation. The rocks are the typical greenish silty and sandy clays of the Tehama. At a depth of 1,432 feet, 14 feet of Nomlaki tuff was cored, and at 1,464 feet, 4 feet of white vitric tuff was found. The following 722 feet was drilled through pale greenish clays with subordinate amounts of sandy clay, sand, and fine gravel. At least 2,000 feet of Tehama sediments were found in this well above the next formation, which occurs at a depth of 2,190 feet.

Heavy minerals from some of the well samples show admixtures from the Nomlaki tuff as well as minerals such as lawsonite, glaucophane, and chromite, which indicate a Franciscan (western) source. In addition, augite and olivine in some samples indicate Tuscan (eastern) source—further proof of the interfingering of the Tuscan-Tehama formations.

Immediately below the Tehama formation is 10 feet of basalt similar to the basalt that caps the buttes.

Just below the basalt, typical dark-gray Cretaceous shale was encountered, and a core collected.

The 10-foot layer of basalt is either a flow poured out upon the surface of the Cretaceous rocks before deposition of the Tehama, or

a sill intruded along the Cretaceous-Tehama contact, the fine-grained character of the basalt indicating the former possibility. Later, basalt and Cretaceous beds were elevated along a fault located at the western margin of the buttes (fig. 7). There is a suggestion of a feeding dike between Middle and South Buttes, for large blocks of basalt are in alignment on the north side of South Butte, and it seems unlikely that they are blocks derived from the buttes themselves.

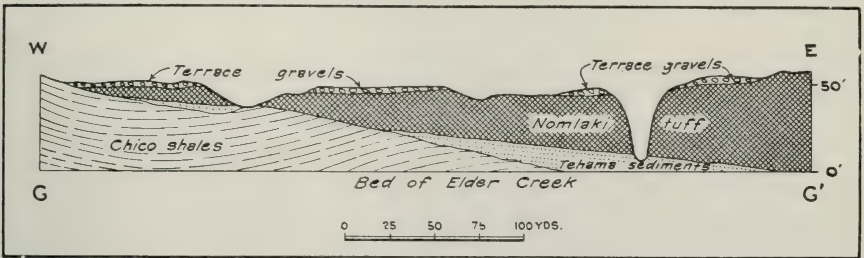

FIG. 8. Cross-section on Elder Creek.

Elder Creek: The Nomlaki tuff is well exposed on Elder Creek and small tributaries (T.25N.,R.6W.). A few feet of red terrace gravels (Red Bluff?) overlie the tuff and 18 feet of silts and sandy clays of the Tehama formation. The conformable Tehama clay-Nomlaki tuff sequence overlaps upon the Cretaceous, in which a small flat syncline is developed (fig. 8).

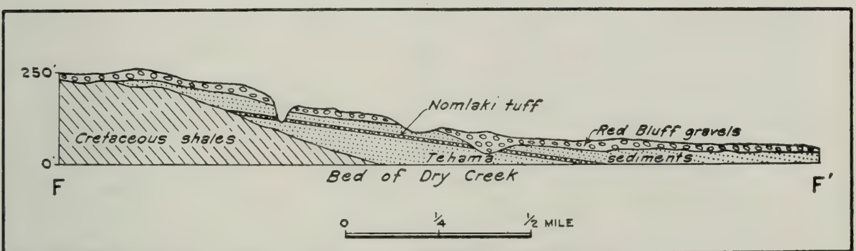

FIG. 9. Generalized cross-section west-northwest from Rosewood along Dry Creek and into the hills immediately north of the creek.

Dry Creek near Rosewood: One of the best exposed and most complete sections of the Tehama formation at its western border occurs along Dry Creek in the vicinity of Rosewood (T.28N.,R.6W.). Here the Nomlaki tuff is 10 feet thick with conformable Tehama sediments above and below. These sediments consist of light yellowish brown, (rarely reddish brown) massive, fine-grained silty sands, sandy silts, and clays with interbedded lenses of fine gravel. The latter are cross-bedded, with the fore-set beds on the east. The Tehama and Nomlaki tuff dip east at low angles (about 2 degrees) and overlap upon the Cretaceous. They are unconformably overlain by coarse red gravels of the Red Bluff formation (fig. 9).

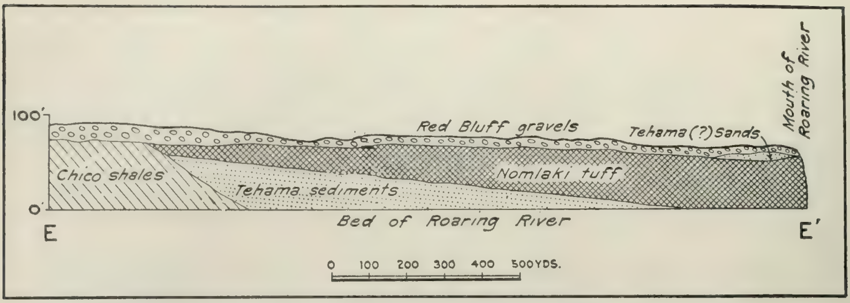

FIG. 10. Generalized cross-section along Roaring River.

Roaring River: A 40-foot section of the Nomlaki tuff is well exposed on the North Fork of Cottonwood Creek near the mouth of Roaring River (T.29N.,R.6W.). Tehama gravels are exposed below the tuff 400 yards upstream from the mouth of Roaring River, and are underlain by massive yellow-brown medium-coarse-grained sandy silt. The surface cut on the Cretaceous rocks rises steeply so that the Nomlaki tuff and Tehama sediments abut against it (fig. 10). Red Bluff gravels overlie both the Cretaceous and Nomlaki.

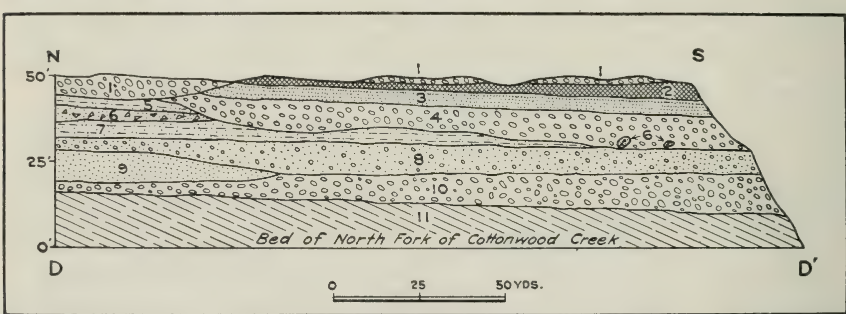

FIG. 11. Section exposed in east bank of the north Fork of Cottonwood Creek near Gas Point: 1. Coarse, red gravels (Red Bluff formation). Boulders up to one and a half feet in diameter. 2. Nomlaki tuff. 3. Pale yellowish-gray, fine-grained sand. 4. Dark reddish-brown gravel, pebbles average one to two inches in diameter but range up to six inches. 5. Pale greenish-yellow gray, fine-grained clayey sands with opal tubules. 6. Fine-grained vitric tuff. Blocks of this tuff in gravel bed (4) near south end of section. 7. Pale gray-green clayey sand. 8. Dark reddish-brown pebbly sand. Pebbles average one third of inch in diameter. 9. Lens of medium to fine-grained sand. 10. Coarse basal gravel, boulders up to one foot in diameter. 11. Gray shales of Chico formation. 2 to 10 inclusive, Tehama formation, thickness 30 to 40 feet.

Vicinity of Gas Point: The section (fig. 11) at Gas Point along the east bank of the North Fork of Cottonwood Creek nicely illustrates the channeling of the finer sediments by the streams which deposited the coarser ones, a condition found throughout the Tehama formation, but especially well developed near its outer borders. The sediments here differ from most of the Tehama sediments in the higher percentage of gravels and large size of boulders in the basal bed. This is the only locality where boulders one foot in diameter were found; 6 inches is the usual maximum, even near the borders of the basin, and one to two inches is the average size. The bed of vitric tuff indicates that volcanic activity began before the Nomlaki tuff was deposited.

Redding Quadrangle: The rocks above the basement complex of the Redding quadrangle and adjacent Lassen Peak quadrangle are best exposed east of Redding along Oak Run, Clover Creek, and Cow Creek. The section is as follows:

Age	*Formation*	*Thickness in Feet*
Recent	Alluvium	
	Unconformity	
Pleistocene	Red Bluff	0-100+
	Unconformity	
Lower Pleistocene or Upper Pliocene	Basalt flows	10-100
	Unconformity	
Upper Pliocene	Tuscan tuff breccias	0-100+
	Tuscan-Tehama sediments	0-200+
	Nomlaki tuff	10-300
	Unconformity (?)	
Eocene	Montgomery Creek	50±
	Unconformity	
Upper Cretaceous	Chico	10-300

The Chico beds consist of sandstone, shale and conglomerate, the latter not limited to the base. The Montgomery Creek formation is well exposed on Little Cow Creek east of the 122 degree meridian, but in the Redding quadrangle, outcrops are poor. The presence of the formation is indicated by coal beds at Norton Gulch (NE corner, T. 33 N., R. 2 W.).

The Nomlaki tuff, except at one locality, lies directly and unconformably upon the Chico formation wherever the base is exposed. Typical Tehama sediments are absent in the eastern portion of the Redding quadrangle. The upper Pliocene beds beneath the Tuscan volcanic breccias consist of sedimentary tuffs and tuffaceous sediments of mixed sources; reworked volcanic material from the east has mingled with material from the basement complex of the Klamath Mountains. These rocks have been called Tuscan-Tehama sediments. Some andesitic and basaltic pebbles are found in the gravels, but the major part of the volcanic debris is white biotite-hornblende dacite. Along the road north of Oak Run, Tuscan volcanic breccia (10 feet thick) is interbedded with Tuscan-Tehama sediments. The capping of Tuscan breccia is usually thin in this region (fig. 12), in marked contrast to the areas farther south.

The basalt flows are later than the Tuscan formation; in some localities, the Tuscan and Tuscan-Tehama sediments were completely removed by erosion before extrusion of the lava. Elsewhere the basalt fills old valleys carved in the Tuscan (fig. 12). Since the Tuscan formation is upper Pliocene, these basalt flows may be either upper Pliocene or Pleistocene. Though once part of a continuous flow, they have suffered considerable erosion, which has produced isolated areas; therefore if the basalt is Pleistocene it probably belongs to the early part of that epoch.

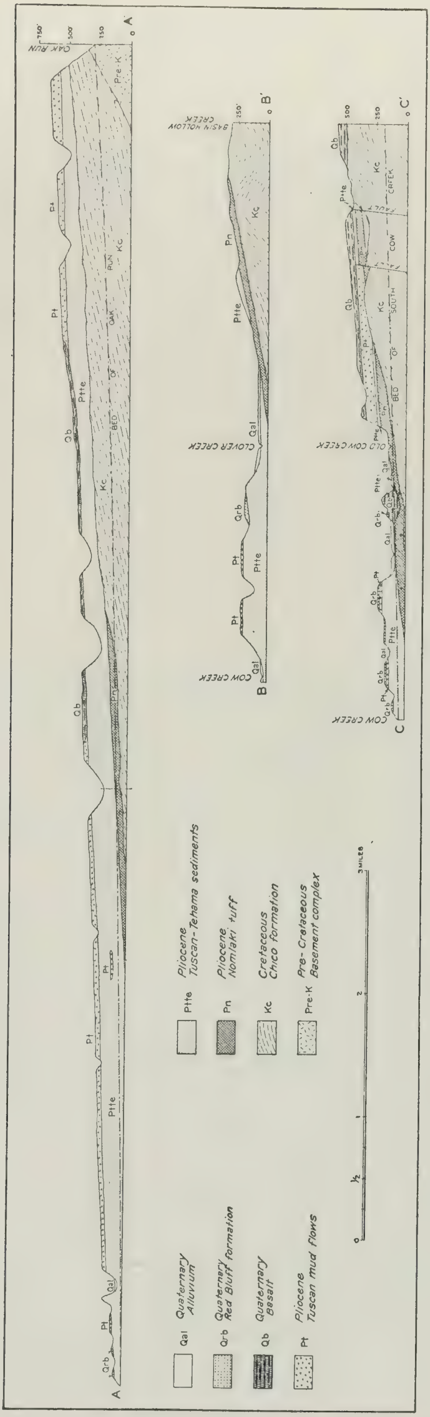

FIG. 12. Cross-sections in the southeastern part of the Redding quadrangle.

Coarse red gravels of the Pleistocene Red Bluff formation overlie the basalt flows with erosional unconformity. Along the Sacramento River east of Redding is the greatest exposed thickness of the formation—slightly more than 100 feet.

The Cretaceous and Tertiary formations dip at very low angles away from the surrounding mountains toward the Sacramento Valley (fig. 12). They are cut by only a few minor faults, and no well developed folds are present.

Composition and Source of Sediments

A petrographic study of the sands, silty sands, and matrix of the gravels of the Tehama formation shows that clay is present in variable amounts except in the tuffs and tuffaceous sediments. Feldspar is an important constituent, orthoclase dominating in the samples from the southwestern area of exposed Tehama. Volcanic glass is important in many of the sediments, particularly those above the Nomlaki, or in those from the area of mixed Tuscan-Tehama. The same is true of rock fragments. Quartz is usually subordinate to the feldspar. The hypersthene present in some samples is probably reworked from the Nomlaki, and the olivine and basaltic hornblende are probably from the Tuscan. These latter two minerals are found in mixed Tuscan-Tehama sediments.

Certain minerals, such as serpentine, chromite, and picotite are derived from the serpentine of the Franciscan in the Coast Ranges, and from the older serpentine of the Klamath Mountains. These minerals are important in the heavy fraction obtained from sediments from the southwestern portion of exposed Tehama. Crossite, glaucophane, and lawsonite are good indicators of a Franciscan Coast Ranges source, and they have been found in the beds along the western margin of the Sacramento Valley.

A sample of Cretaceous sandstone collected from a tributary of Elder Creek contains minerals that are relatively more resistant to decomposition, and the grains are better sorted and rounded than those in the Tehama. Apparently little reworked material from the Cretaceous was added to the Tehama; instead, the sediments were derived directly from the bedrock.

A study of the pebbles from the gravels yielded valuable information as to the source. A Tuscan-Tehama gravel from South Cow Creek, Redding quadrangle, contained 95 per cent volcanic pebbles, the remainder consisting of diorite, chert, and quartzite. The volcanic pebbles indicate an eastern (Tuscan) source.

Along the North Fork of Cottonwood Creek near Gas Point, metavolcanic (Copley meta-andesite) schist, quartz diorite, and granodiorite pebbles indicate a northern and western source. South near Rosewood, the same pebbles plus Devonian slate and chert pebbles indicate the same source. A gravel from Dibble Creek, northwest of Red Bluff contains the same type pebbles plus cherts (Franciscan?) and Franciscan quartz-glaucophane schists. Northwest of Stony Creek Buttes, pebbles of schist and quartz diorites from the Klamath Mountains are found, along with abundant chert pebbles, in part, probably of Franciscan derivation. There is an increase in the number of

serpentine pebbles to the south; these probably represent a Coast Range source for the sediments of this region.

The pebbles in the Tehama gravels have not been derived to any appreciable extent from the Cretaceous conglomerates, for the pebbles in the latter are well rounded, while those in the Tehama are subangular. The rare well-rounded pebbles in the Tehama gravels are probably reworked from Cretaceous conglomerates.

Late Pliocene Topography

The Tehama formation furnishes some definite evidence of the topography of the region during the last third of the Pliocene. At each locality visited, the pebbles and boulders in the present streams and in the Red Bluff formation, where the latter is present, include almost the same list of rock types found in the Tehama at the same locality. The present stream deposits are coarser than the Tehama sediments, but not as coarse as the Red Bluff gravels. The presence of the same rock types in the upper Pliocene sediments and in the present streams cannot be explained, therefore, as the result of derivation of the pebbles in the latter from the Tehama gravels, nor is the detritus of the present streams derived to any appreciable extent from the Red Bluff. In view of these facts it appears that the distribution of exposures of the pre-Tehama rocks and the general trend of stream courses has remained approximately the same from the upper Pliocene to the present. Since the major features of the present drainage pattern are dependent upon the presence of a broad elongate valley surrounded by mountains on three sides (fig. 2), the general topographic setting in upper Pliocene and Pleistocene must have been similar. However, there is no indication that the relief was necessarily the same during these three epochs.

The Tehama sediments are finer than the later deposits. This condition can be explained by (1) a more limited but evenly distributed Pliocene rainfall, or (2) an even distribution of rainfall as compared to the present climate; or (3) a lower relief during the later Pliocene than at present. According to Dorf,[35] the climate of the later Pliocene was slightly more humid than the present, but almost as markedly seasonal; therefore it is probable that the cause of the finer Tehama sediments was a lower relief than that of today, resulting in lower stream gradients, and, consequently in finer stream detritus. There is no evidence that the Tehama sediments were deposited in a closed basin; instead, it is probable that conditions were like those found today in the alluviated Sacramento Valley, where comparable sediments are now being deposited. This flat portion of the present Sacramento Valley begins to narrow rapidly north of Chico, and ends at Red Bluff (fig. 2). If it were extended north and west, the conditions during the upper Pliocene would be closely approximated (fig. 1). The Tehama surface was not only of low relief, but also of low elevation above sea level.

Progressive subsidence of this region must have taken place during upper Pliocene time, for in the Orland Syndicate Well, Tehama sediments extend to a depth of 2,190 feet or over 1,800 feet below sea level. The sediments do not show a progressive decrease in grade size from bottom to top, judging from a study of the cores of the well,

[35] Dorf, Erling, Pliocene floras of California: Carnegie Inst. Wash. Pub. 412, p. 66, 1930.

but are fairly uniform. Therefore subsidence of about 1,800 feet must have taken place concomitant with the deposition of the sediments.

At least two periods of uplift have occurred since deposition of the Tehama. The first is shown by the upwarped margins of the Tehama and has resulted in a homoclinal structure on the west side of the Sacramento Valley. Subsequent to this tilting, the Tehama and Mesozoic formations were truncated by erosion, forming a surface of low relief upon which the Red Bluff gravels rest. A second period of uplift is demonstrated by the fact that this surface has been deformed, and probably also tilted toward the axis of the valley. The deformation has formed at least one broad arch and several local folds.

Nomlaki Tuff

Character and Distribution. In addition to its value as a horizon marker in the Tehama formation, the Nomlaki tuff possesses other characters of importance. It is exposed for a distance of 40 miles along the west side of the Sacramento Valley, and is somewhat variable in its thickness. It is pale gray or salmon-pink in color, poorly consolidated, and composed of white pumice fragments in a matrix of glass and crystal fragments (fig. 13). It is massive in structure and only locally has it been reworked by streams.

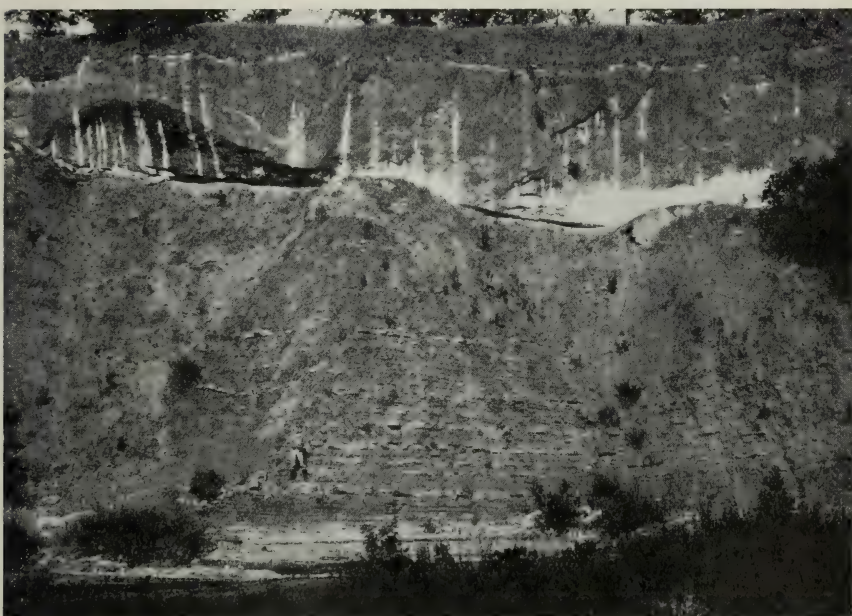

FIG. 13. Nomlaki tuff (upper Pliocene) overlying shales of the Chico formation (upper Cretaceous) and capped with terrace gravels. Elder Creek, at west end of section shown in Fig. 8. Looking northeast.

The most southerly exposure of the tuff is in Stone Valley (NE corner of T.20N.,R.5W.), where it is 15 feet thick. White pumice fragments are rare, and usually less than one half inch in diameter. The next exposure is 14 miles to the north where the tuff is 30 feet thick with white pumice fragments up to 4 inches in diameter.

The type locality of the Nomlaki tuff is at the former headquarters of the old Nomlaki Indian reservation about 6 miles northeast of Paskenta. Here the tuff has been quarried. The section as exposed in the quarry and hill is given below:

1. Pale brownish yellow tuffaceous silts	20 feet
2. Light gray tuff with pumice fragments up to one and a half inches in maximum diameter. Upper part re-worked with addition of sedimentary material	10 feet
3. Deep salmon-pink tuff with white pumice fragments up to 8 inches in maximum diameter	2 feet
4. Light salmon-pink tuff with fragments of white pumice up to one and a quarter inches in maximum diameter	10 feet
Base of the tuff not exposed.	

At the type locality, the dip of the tuff is three to five degrees east. The thickest section of Tehama beds exposed beneath the tuff occurs in this area; gravels, silts, and sands of the Tehama formation outcrop to the west for a distance of nearly three miles, indicating a thickness of at least 600 feet between the tuff and Cretaceous.

Along Elder Creek the tuff is 50 feet thick; pumice fragments occasionally reach a foot in diameter. On Dry Creek west of Rosewood the tuff is only 10 feet thick; it has been channeled locally, and contains sedimentary admixtures in the upper portion. Near Gas Point, the thickness is again 50 feet, and pumice fragments of three to six inches are common.

Along the east side of the Sacramento Valley the Nomlaki tuff is exposed, in several of the stream canyons, interbedded with the Tuscan formation near its base. At Tuscan Springs, 8 miles northeast of the town of Red Bluff, 30 to 100 feet of the tuff are exposed in a tributary to Salt Creek. Immediately to the south at Antelope Creek, 40 feet of tuff are present. On Butte Creek, east of Chico, 20 feet appear about 100 feet above the base of the Tuscan. In these latter exposures, the Nomlaki appears to have been reworked in part by streams.

Between Tuscan Springs and the Redding quadrangle, the Nomlaki tuff is not exposed; but in the eastern portion of that quadrangle, numerous exposures are found. Here also the thickness is variable, reaching a maximum of 80 feet on South Cow Creek near its junction with Old Cow Creek. In this region, darker colored pumice fragments appear at the expense of white pumice. Shards of black glass are common, giving the rock a medium gray color. Columnar jointing appears in some of the exposures, and the tuff is moderately indurated.

To the east, along Bear Creek in the Lassen Peak quadrangle, 200 to 300 feet of Nomlaki tuff are exposed, massive and well indurated, and showing well developed columnar jointing, the columns reaching a diameter of five or six feet. Fragments of highly vesicular pumice are rare; instead, dense and slightly pumiceous white, pink, and black glass form most of the fragments, which are usually less than six inches in diameter. Long drawn out stringers of gray to black glass

show a sub-parallel arrangement (fig. 14). These stringers branch into fine and delicate filaments which are not broken, but are continuous with the main mass of the glass fragment.

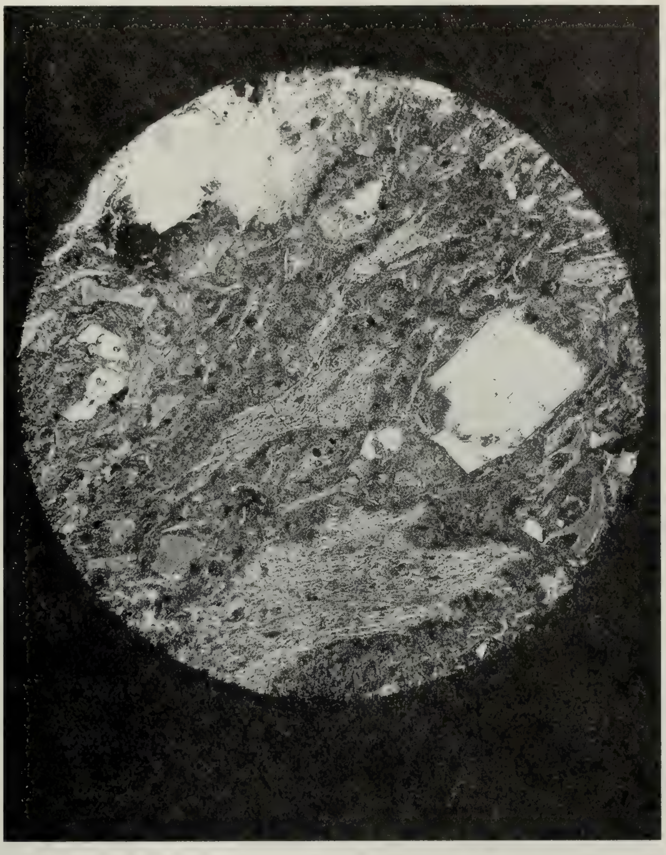

FIG. 14. Photomicrograph of the Nomlaki tuff showing vitroclastic texture and glass streak branching into fine filaments. From Bear Creek, Shasta County. 40X.

An enormous volume of volcanic ejecta is represented by the Nomlaki tuff, for it must have covered an area of at least 2,000 square miles. The thickness is variable, but assuming an average thickness of only 25 feet, (a minimum value) a total value of nine and one half cubic miles is represented. It must be remembered that the tuff contains much pumice, and hence represents a considerably smaller volume of massive rock.

Source and Mode of Emplacement. The Nomlaki tuff increases in thickness to the northeast of the Sacramento Valley, culminating in 300 feet along Bear Creek. In these thick exposures, columnar jointing indicates that the tuff was hot at the time of deposition, and suggests proximity to the source. There is also an increase in the number of the heavy elements, such as andesite and dacite fragments, indicating that the source was in this vicinity.

In the region east of Manton, along Digger Creek, pumiceous biotite-hornblende dacite tuff is exposed. This pumice is similar to that in the Tuscan-Tehama sediments of the Redding quadrangle. In this area of tuff, also, massive hypersthene-hornblende dacite occurs, suggestive of an ancient dome similar to the more recent protrusive domes of the Lassen Peak region.[36] The lava of this dome is gray, black, and red in color, containing phenocrysts similar to those in the Nomlaki tuff and in about the same proportions. Anderson has recently discovered small areas of similar dacite north of Viola suggesting that this general area represents the location of the old volcanoes which supplied the ejecta composing the Nomlaki tuff.

The widespread distribution of this massive tuff, which contains numerous pumice fragments and glass-rich fragments, limits the possible modes of emplacement. Obviously it was not formed by explosive eruptions hurling ejecta more or less vertically into the air (vulcanian eruptions), for tuffs of such origin are sorted and stratified. A mudflow origin can be eliminated; for it would be necessary for a mudflow, after descending the eastern slope of the old valley, to cross its flat expanse for a distance of 10 to 40 miles, and to travel part of the way up a low but noticeable gradient.

The characteristics of the Nomlaki tuff suggest that it was distributed by gigantic Peléan eruptions, or "burning clouds". These are flows of intensely hot gas-rich fragments, in which each fragment rapidly and continuously emits its gas. The fragments are enveloped and cushioned by this gas so that the flow has the appearance of a "burning or glowing cloud." Such a cloud moves rapidly even over a gentle slope, aided by gravity; its extreme mobility is due to lack of friction between the gas enveloped fragments. The glass filaments, the flattened pumice fragments, and the tenacity of the Nomlaki tuff in the region around Bear Creek indicate compaction and welding of hot ejecta, typical of many Peléan deposits recently described by Gilbert.[37] Along the western margin of the Sacramento Valley, at the distal margins of the Nomlaki tuff, welding is absent, no doubt owing to the distance from the source vents, allowing considerable cooling at the time of deposition. There is some rude stratification along this belt, suggesting that several "flows" of tuff may be represented, but there is no evidence of reworking of the deposit between the periods of deposition represented by the rude bedding. The Nomlaki tuff undoubtedly represents a rapid succession of Peléan eruptions on a magnificent scale, the deposit accumulating within a few days or weeks.

Petrography and Chemical Composition. The Nomlaki tuff is essentially a hornblende hypersthene dacite crystal vitric tuff containing some rock fragments (andesites and dacites). The glass of the tuff ranges in index of refraction from 1.497 to 1.503. The feldspar is usually sodic andesine, but some zoned crystals range from labradorite to oligoclase. In thin section, typical bogen structure, characteristic of vitric tuffs, is revealed (fig. 14). Tuff from the Bear Creek area

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[36] Williams, Howel, The volcanic domes of Lassen Peak and vicinity, California: Am. Jour. Sci., vol. 18, p. 313, 1929.

[37] Gilbert, C. M. Welded tuff in eastern California: Geol. Soc. Am. Bull., vol. 49, pp. 1829-1862, 1938. This paper contains a good bibliography and discussion of Peléan eruptions and welded tuffs.

contains delicate glass filaments formed by welding of the intensely hot glass fragments.

Chemical analyses show the dacitic character of the tuff in spite of the absence of quartz.

	1	2	3	4
SiO_2	65.78	67.27	69.51	68.10
Al_2O_3	14.87	14.84	15.61	15.50
Fe_2O_3	1.27	1.01	.56	3.20
FeO	1.00	.85	1.27	none
MgO	1.89	1.36	.61	.10
CaO	2.41	2.30	2.80	3.02
Na_2O	2.58	2.94	3.43	4.20
K_2O	2.71	2.87	2.81	3.13
H_2O (—)	2.87	1.55	----	----
H_2O (+)	4.32	4.95	3.63	2.72
P_2O_5	.08	.06	----	.03
TiO_2	----	.27	tr.	.15
BaO	----	.15	----	.06
	99.78	100.42	100.23	100.21

1. Rice's Quarry (old Nomlaki Indian reservation headquarters), 6 miles N.E. of Paskenta. Analysis by George Steiger. Clarke, F. W., and Hillebrand, W. F. Analyses of rocks: U. S. Geol. Survey Bull. 148, p. 194, 1897. (The locality is erroneously given as six miles S.E. of Paskenta.)

2. Same locality. Analysis by E. T. Allen. Diller, J. S., Klamath Mountain Section, California: Am. Jour. Sci., vol. 15, p. 360, 1903. (Diller reprinted analysis number one in this article and gave the correct locality.)

3. Stillwater Creek, 8 miles northeast of Redding. Analysis by W. H. Melville. Clarke and Hillebrand, *op. cit.*, p. 197.

4. Falls of South Fork of Bear Creek, Shasta County. Analysis by R. B. Riggs. Clarke and Hillebrand, *op. cit.*, p. 194.

Analyses 3 and 4 are erroneously listed as andesite tuff and streaked dacite (flow), respectively. Their mineral and chemical composition, and the field evidence, clearly indicate that both exposures are Nomlaki. The Bear Creek Falls "streaked dacite" is the welded tuff with well-developed columnar jointing.

Undifferentiated Volcanics

Along the southwestern edge of the Cascade Range, a number of eroded hornblende and pyroxene andesite volcanoes rise above the basalt flows. Comparatively little is known concerning the relations of these volcanoes, except that flows from them overlie the Montgomery Creek formation. In some areas, andesites overlie the Tuscan formation, but some of the volcanoes may be earlier. (At present, C. A. Anderson is studying the volcanic sequence in the region north of Viola.) To the east of the area many of the volcanoes are of Pleistocene and Recent age.

Western Border of the Sierra Nevada

As previously mentioned, the northern limit of the Ione formation is at Oroville Table Mountain, 20 miles southeast of Chico (fig. 1).

Ten miles to the north of Oroville, on the northern side of Oroville Table Mountain, gray shales, overlain by biotite sandstones, locally glauconitic, lie between the Ione and Cretaceous formations. Allen[38] has called these beds the Dry Creek formation; recently Merriam and Turner,[39] stated that the invertebrate fossils which they contain indicate a middle Eocene age (Capay stage). The lithology is distinct from that of the Ione; but the mineral composition is similar to that of the underlying upper Cretaceous (Chico), biotite, plagioclase, and orthoclase giving evidence of little chemical weathering of the source rocks.

[38] Allen, V. T. The Ione formation of California: Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 18, pp. 366-372, 1929.

[39] Merriam, C. W. and Turner, F. E. The Capay middle Eocene of northern California: Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 24, pp. 91-114, 1937.

White rhyolitic clays and tuff overlie the Ione formation with a disconformity at many localities along the western border of the Sierra Nevada, and apparently are contemporaneous with the rhyolite tuffs which occur farther up the slope. The thickness is variable, being largely dependent upon the topography of the surface upon which the tuffs accumulated. The thickest deposits are in old valleys. The thickness ranges from less than 100 feet along the lower slopes of the Sierra Nevada to a maximum of 200 feet on the middle slopes. No definite evidence is available for the dating of these rhyolitic tuffs but estimates range from late Eocene to middle Miocene. Not all of the tuffs are rhyolitic. At La Porte, 40 miles east of Chico, white tuffs overlying the middle Eocene bench gravels have been determined as dacitic, and contain an upper Eocene or lower Oligocene flora.[40] It is hoped that studies of these Sierran tuffs in the immediate future will give us additional information on this subject. At many places on the western flanks of the Sierra Nevada, andesitic breccias, tuffs, conglomerates, and sedimentary tuffs, similar in appearance and character to the Tuscan formation and undoubtedly of similar origin, overlie the rhyolitic clays and tuffs. Good evidence is available for the dating of many of these andesitic rocks as upper Miocene or lower Pliocene.[41] However Clark and Anderson[42] have shown recently that some of the andesitic rocks on the lower slopes of the Sierra Nevada are of upper Eocene or lower Oligocene age, and in one case, rhyolitic tuffs overlie the andesites. Thus caution must be used in correlating the volcanic tuffs and breccias from one locality to another.

Marysville Buttes

The Marysville Buttes provide a conspicuous landmark in the central part of the Sacramento Valley, their jagged peaks rising to a height of over 2,000 feet. Their volcano-like aspect is obvious to the most casual observer; they represent an ancient volcanic center which has had an interesting and complex history, ably described by Williams.[43] whose paper is the source of the following brief notes.

The oldest rocks exposed are sandstones with interbedded conglomerates, gray limestones and gray to black shales of upper Cretaceous Chico age, aggregating about 1,500 feet in thickness. According to Williams,[44] recent discoveries of invertebrate fossils indicate that white sands on the south side of the buttes, considered Ione (middle Eocene) in his published study, are in reality interbedded with Cretaceous sediments. These recent discoveries limit the thickness of the rocks previously assigned to the Eocene. Above the Cretaceous, particularly on the southwest side of the buttes, sediments lithologically similar to

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[40] Potbury, S. S. The LaPorte flora of Plumas County, California: Carnegie Inst. Wash. Publ. 465, pp. 29-81, 1935.

[41] Louderback, G. D. Period of scarp production in the Great Basin: Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 15, p. 144, 1924.

Louderback, G. D. Notes on the geologic section near Columbia, California, with special reference to the occurrence of fossils in the auriferous gravels: Carnegie Inst., Wash. Publ. 440, pp. 7-13, 1933.

Merriam, J. C. and Stock, Chester. Tertiary mammals from the auriferous gravels near Columbia, California: Carnegie Inst. Wash. Publ. 440, pp. 1-6, 1933.

[42] Clark, B. L., and Anderson, C. A. Wheatland formation and its relationship to early Tertiary andesites in the Sierra Nevada: Geol. Soc. Amer. Bull., vol. 49, pp. 931-956, 1938.

[43] Williams, Howel. Geology of the Marysville Buttes, California: Univ. Cal. Publ. Bull. Dept. Geol. Sci., vol. 18, pp. 103-220, 1929.

[44] Oral Communication.

the Cretaceous contain invertebrate fossils of middle Eocene age (Capay stage).[45] Apparently above these beds, 100 to 150 feet of quartz anauxite sands, similar to the Ione formation along the foothills of the Sierra Nevada, appear below coarse gravels with sandy intercalations (Butte gravels), which also contain a middle Eocene (Capay) invertebrate fauna.

The Sutter beds, ranging from 500 to over 1,000 feet in thickness, overlie the Butte gravels. They consist chiefly of rhyolite tuff at the base and andesitic tuffaceous sediments above. Williams considers these sediments to have been derived from the Sierra Nevada, and assigns them to the "Middle Neocene" (upper Miocene or lower Pliocene).

Williams has outlined this history[46] for the time following the deposition of this series of sediments:

"* * * g. The aggressive intrusion of a "steep-dome laccolith" of andesite porphyry during the middle or late Pliocene period, upturning the adjacent sediments and producing in them a plexus of faults, disposed both radially and concentrically with respect to the laccolithic margins.

"h. Erosion of the sedimentary cover from the top and sides of the laccolith down to a level almost identical with that of the sediments as now exposed.

"i. Intrusion of rhyolitic necks or domes into both the andesites and the upturned sediments, folding the latter still farther, accompanied by minor eruptions.

'j. Continued erosion resulting in the formation of deep valleys among the sediments on the flanks of the laccolith, particularly along the radial fault lines.

"k. A series of violent steam explosions, chiefly from a central crater in the core of the laccolith, involving the comminution and ejection of masses of solid andesite and rhyolite as tuff and breccia.

"l. Erosion and removal of much of the andesite tuff and breccia so as to expose what is almost the pre-eruption surface of the sedimentary hills."

The tuff and breccia produced by the steam explosions form the outer portion of the buttes; within lies the ring of sediments, which dip steeply away from the central part. The latter consists of massive andesite of the original laccolith together with rhyolite intrusives, and a core of tuff that represents the vent from which the explosions came. On the accompanying geologic map all the volcanics have been mapped together, as have the Eocene formations.

Rumsey Hills

The series of low hills along the eastern border of the Coast Ranges between Capay and Williams in Yolo and Colusa counties is locally known as the Rumsey or Hungry Hollow Hills. Immediately east of Capay Valley, the Cretaceous beds, which are folded into a steep anticline faulted along the western limb, form the core of the hills and are surrounded by Tertiary sediments of Eocene and Pliocene age.

The name Capay formation was given to the Eocene sediments by Crook and Kirby,[47] who stated that the deposits reach a maximum thickness of 2,500 feet. The sediments grade from channel conglomerates in tilted Cretaceous shales at the north end to presumably estuarine deposits of sandstone and shale. Fossils were collected south of Guinda about 450 to 500 feet stratigraphically above the Cretaceous and, according to Merriam and Turner,[48] these indicate a middle Eocene age (Capay stage) intermediate between the Meganos and Domengine.

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[45] Merriam, C. W., and Turner, F. E., *op. cit.*, footnote 38.
[46] *Op. cit.*, p. 113.
[47] Crook, T. H., and Kirby, J. M. Capay formation: Geol. Soc. Amer. Proc. for 1934, pp. 334-335, 1935.
[48] *Op. cit.*

Unconformably overlying the Cretaceous and Eocene is a series of fluviatile beds, composed of gravels, sands, silts, and clays with interbedded tuffs, indicated on the map as Tehama formation. Apparently these beds represent an alluvial fill, much like the Tehama to the north, except that more gravels appear in the Rumsey Hills. The source of these sediments was undoubtedly the Coast Ranges. They contain typical Coast Range minerals and pebbles (cherts, glaucophane schist, serpentines, etc.). Correlation with the Tehama formation has been strengthened by the discovery of a fragment of the lower jaw of a horse, five miles west of Woodland, on the north side of Cache Creek. According to V. L. Vander Hoof,[49] the fossil came from light green to gray clay and sandy clay, overlain by cross-bedded coarse, rounded, carbonaceous sand and light clayey fine sand. These sediments are capped by soil and reddish gravels (Red Bluff), the total section measuring 20 feet. Vander Hoof has provisionally determined the fossil as Equus, which indicates either an upper Pliocene or Pleistocene age; however, the character of the beds below the reddish gravels suggest that they are older than the Pleistocene, and that they are of upper Pliocene age, and can be correlated with the Tehama.

The interbedded tuff differs from the Nomlaki tuff in that the refractive index of the glass is higher, and plagioclase is more abundant and more sodic in composition. Furthermore, it contains less hornblende and hypersthene and more augite. Apparently the tuff is not related to the Nomlaki, and a different source would be expected; but not enough information is available to make additional suggestions.

[49] Personal communication.

ECONOMIC GEOLOGY

Metals

A small amount of gold has been recovered from some of the Tertiary formations of this region. Diller [50] has noted that the Montgomery Creek sediments have been locally panned for gold, but the recovery has not been sufficiently great to induce exploitation. This statement also applies to the Tehama formation. The gravels from recent streams and the Pleistocene Red Bluff, however, have yielded considerable quantities of gold, and in the area fronting the Coast Ranges, a small amount of platinum.

Building Stone

The only Tertiary rock in this region suitable for building purposes is the Nomlaki tuff. It is light, easily worked, yet tenacious, and has been used for chimneys, smoke houses, etc. The tuff has been quarried to some extent on South Cow Creek, 3 miles east of Millville, and at the headquarters of the old Nomlaki Indian Reservation in Tehama County.

Groundwater Resources

The groundwater resources of the Sacramento Valley have been ably discussed by Bryan [51] and, according to him, the ''younger alluvium'' is the most productive water bearer. The majority of dug wells produce from sands and gravels of Recent age. Many good wells, however, produce from the Tehama and Red Bluff formations ''older alluvium,'' according to Bryan. Wells producing from these formations are usually drilled rather than dug, owing to the greater induration of the older beds. Gravel beds in the Tuscan formation on the east side of the valley also yield some good wells.

Coal

The Montgomery Creek formation carries a considerable amount of lignitic and sub-bituminous coal, reported many years ago by Goodyear.[52] Prospect tunnels have been driven in the coal at many localities. The coal seams occur in the basal portion of the formation and are distributed through a thickness of 200 feet. The number of seams varies between one and five, but usually only one or two of these are of workable dimensions. The thickness of the individual seams that have been prospected varies between one and six feet. The most southerly outcrops of coal occur on Cow Creek. As far as is known at present, there is little coal between Cow Creek and Clover Creek, but between Clover Creek and a point two miles south of the town of

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[50] Diller, J. S. Geology of the Lassen Peak district: U. S. Geol. Survey, 8th Ann. Report, pt. 1, p. 414, 1887.

[51] Bryan, Kirk, Geology and ground-water resources of Sacramento Valley, California: U. S. Geol. Survey, Water Supply Paper 495, 295 pp., 1923.

[52] Goodyear, W. A., Coal in California: Calif. State Mining Bureau, 7th Ann. Report, pp. 149-150, 1880.

Montgomery Creek, the coal appears to be continuous. In the vicinity of Wengler and Big Bend, coal is absent; some coal has been prospected in the small area of Montgomery Creek formation at the head of Kosk Creek. A few years ago the Mt. Shasta Coal Company was organized to exploit the coal, but the discovery of the Kettleman Hills gas field has prevented development because of the reduction in price of fuel.

Mr. Charles Magill, mining engineer of the Southern Pacific Railroad, was employed by the Mt. Shasta Coal Company as consulting engineer, and he made a detailed study of the coal resources of the Montgomery Creek formation between Clover Creek and Montgomery Creek. His report has been made available through the courtesy of Mr. G. S. Sielaff, geologist of the Southern Pacific Railroad, and Mr. P. B. Cross of the Mt. Shasta Coal Company. The following statements have been taken from Mr. Magill's report.

The width of the coal field is indeterminate but is at least three and one-half miles. The length is 13 miles, of which 9 miles can be economically mined. Estimating 1,500 tons of coal to the acre-foot and the thickness of the workable beds at five feet, Magill calculated that 575 acres of land leased by the Mt. Shasta Coal Company in the Barnes Ridge area (between Clover Creek and Little Cow Creek and adjacent areas) would yield 4,312,500 tons of coal. On the same basis of calculation, an additional 7,860,000 tons underlies privately owned lands in the vicinity, making a total of over 12,000,000 tons of coal in this portion of the Montgomery Creek formation.

The following analyses show the coal to be a fair grade of high-moisture, sub-bituminous fuel. Experiments made by the Mt. Shasta Coal Company indicate that when crushed and fed by air blast, the coal is quite suitable for use in boilers.

ANALYSES OF THE COAL

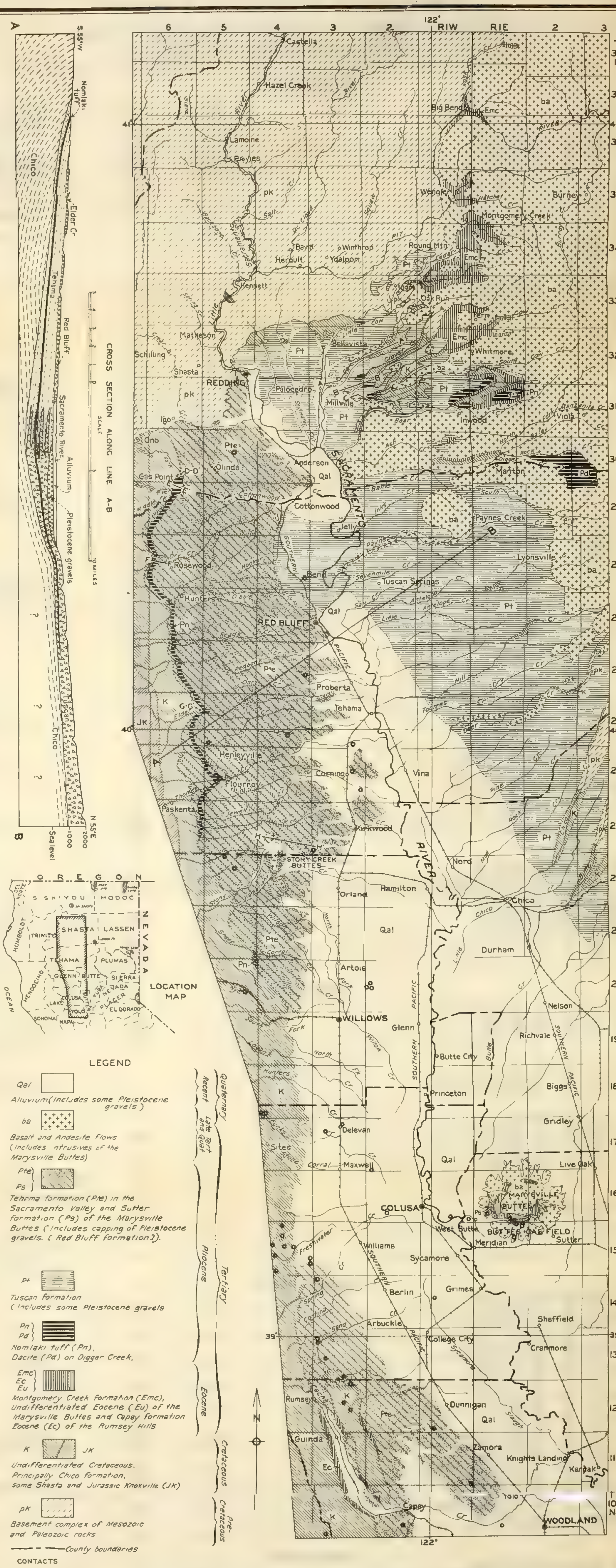
	Moisture	*Volatiles*	*Fixed C.*	*Ash*	*S*	*BTU*
1. ----------	13.20	27.80	33.20	25.80	0.90	n.d.
2. ----------	13.10	29.10	30.60	27.20	0.60	n.d.
3. ----------	12.80	33.70	35.80	17.70	0.97	n.d.
4. ----------	11.40	32.50	29.90	26.20	0.81	n.d.
5. ----------	10.46	34.08	34.39	21.07	n.d.	8,230
6. ----------	12.10	32.90	33.50	22.60	n.d.	8,055
7. ----------	12.55	36.20	34.31	16.94	n.d.	8,462
8. ----------	n.d.	n.d.	n.d.	13.64	n.d.	9,592
9. ----------	12.10	33.95	26.69	24.26	0.56	7,618

Samples 1 to 4, inclusive, quoted from Magill's report; analyst not given. Samples 5 to 9, inclusive, made for the Mt. Shasta Coal Co. Sample 5 analyzed by P. G. & E. Co.; samples 6, 7, 8, and 9 by Smith Emery Co., San Francisco.

1. Taken across lower four foot bed in Luce adit, 350 feet from entrance.

2. Taken across upper four foot bed in Luce adit, 350 feet from entrance.

3. Taken across upper two foot bed in Dakin adit, 225 feet from entrance.



RECONNAISSANCE GEOLOGIC MAP
OF THE TERTIARY OF NORTHERN
SACRAMENTO VALLEY

COMPILED FROM VARIOUS SOURCES
WITH ADDITIONAL FIELD DATA
BY
R. DANA RUSSELL

SCALE
0 5 10 15 20 25 MILES

1931
REVISED (1939) BY C A ANDERSON

List of Wells Drilled by Oil and Gas Companies

Compiled by OLAF P. JENKINS, Chief Geologist, Geologic Branch, State Division of Mines

Locations Shown on Geologic Map of Northern Sacramento Valley by Anderson and Russell

(*Source of data:* State Division of Oil and Gas; State Division of Mines; Petroleum World; and other published and unpublished sources.)

COLUSA COUNTY

Location	*Name*	*Year abandoned or last active*	*Depth (feet)*	*Geology (bottom of hole*
T. 18 N., R. 4 W., M. D. M.				
Sec. 31	Continental Oil Co. Well No. "Patterson" 1-A	1929	4277	Cretaceou
Sec. 31	Continental Oil Co. Well No. 1	1925	1876	Cretaceou
Sec. 31	Mutual Oil Co.	1925	2090	Cretaceou
T. 17 N., R. 3 W., M. D. M.				
Sec. 3	Sacramento Valley Irrig. Co.	1937	832	
Sec. 8	Jackson, Wm. P. No. 1	1934	855	Cretaceous
T. 17 N., R. 2 W., M. D. M.				
Sec. 31	Maxwell Oil Co. No. 1	1931	1780	Cretaceous
T. 16 N., R. 5 W., M. D. M.				
*Sec. 36	Empire Oil & Gas Corp. Well "Dunlap" No. 1	1939		
T. 16 N., R. 2 W., M. D. M.				
Sec. 28	Smith & Vickers No. 1	1933	960	
T. 16 N., R. 1 W., M. D. M.				
Sec. 34	Amerada Pet. Corp. (Calif. Lands Colusa 1)	1938	8152	
T. 15 N., R. 4 W., M. D. M.				
Sec. 4	Colusa Oil Co. Harlan No. 1	(?)	1100	Cretaceous
*Sec. 7	Mountain House Oil Co. Well No. 1	1922	711	
*Sec. 7	Williams Oil Co. "Thompson" No. 1	1908	800	
Sec. 15	Empire Oil & Gas Corp. Well No. "Seaver" 1	1939	105	
Sec. 16	Williams Oil Co. "Brim" No. 1	1902	2540	Cretaceous
Sec. 17	Williams Oil Co. "Vangilt" No. 3	1907	1810	Cretaceous
*Sec. 18	E. & G. Products Co. Well "Evans" No. 1	1929	148	
*Sec. 18	Smith & Vickers Well No. 1	1931	1028	
*Sec. 18	Mountain House Oil Co. Well No. 5	1931	1322+	
*Sec. 19	Evans-Carter No. 1	1929	306	
Sec. 20	Williams Oil Co. "Freshwater Creek Well"	1865	800	
Sec. 25	Birch Ranch Oil Co. and Irwin S. Burgess "Stovall-Wilcoxson" No. 1	1936	800	
Sec. 25	Birch Ranch Oil Co. and Irwin S. Burgess "Stovall-Wilcoxson" No. 2	1939		(Drilling)
*Sec. 31	Brown and Foster No. 1	1929	930	
*Sec. 31	W. T. Jacobs Well No. 1	1925	925	
*Sec. 31	W. T. Jacobs Well No. 2	1929	721	
*Sec. 31	W. T. Jacobs Well No. 3	1929	828	
*Sec. 31	W. T. Jacobs Well No. 4	1933	160±	
*Sec. 31	Colusa Oil Co. "Bush" No. 4	(?)	1040	
*Sec. 31	Williams Oil Co. No. 5	1861	360	Cretaceous
Sec. 32	Smith & Vickers No. 1	1937	1040	Cretaceous
T. 14 N., R. 5 W., M. D. M.				
*Sec. 1	American Chemical Co. "King" No. 1	(?)	925	
*Sec. 2	E. & G. Products Co. No. 1	1930	1073	
*Sec. 21	Young Oil Co. Well No. 1	1923	100±	
*Sec. 21	D. & M. Oil Co. Well No. 1	1937	516	
*Sec. 23	Grover-Herring Well No. 1	1931	1000	
*Sec. 27	Kossik Jones	(?)	(?)	
*Sec. 27	Amalgamated Oil Co. of Nevada Well No. 1	1929	2848	
*Sec. 27	Empire Oil & Gas Corp. "Grandfather Fuiger Well"			
*Sec. 27	Meeker, Leslie F. "Grandfather"	drilled 1844	105	
*Sec. 35	Herron Oil Co.	1901	1000±	Serpentine
T. 14 N., R. 3 W., M. D. M.				
Sec. 6	Birch Ranch Oil Co. and Irwin S. Burgess "Johnston" No. 1	1936	540	
T. 14 N., R. 1 W., M. D. M.				
Sec. 17	Prize Oil & Gas Co. No. 1	1932	870	Cretaceous
T. 13 N., R. 3 W., M. D. B. & M.				
Sec. 7	Gorrell & Smith	1900	543	
Sec. 7	Youle Oil Co.	prior 1901	1200±	
Sec. 20	Allied Pet. Corp. "Blevins" No. 1	1932	2043	Cretaceous
Sec. 34	Blue Ridge Pet. Co. No. 1	1922	2946	

GLENN COUNTY

T. 22 N., R. 5 W., M. D. M.				
Sec. 4	E. F. Stella, Trustee, No. 1	1937	4697	
Sec. 10	E. F. Stella, Trustee, Well No. "Murdock-Simpson"	1936	1145	
T. 20 N., R. 5 W., M. D. M.				
Sec. 23	Williams Oil Co.	1902	2900	Chico (Cretaceous)
T. 20 N., R. 2 W., M. D. M.				
Sec. 18	Ohio Oil Co. "E. E. Willard" 1	1938	4505	
Sec. 18	"E. E. Willard" 1-A	1938	6014	(gas blowout)
Sec. 18	"E. E. Willard" 2	1938	2253	

NAPA COUNTY

T. 10 N., R. 3 W., M. D. M.				
Sec. 32	Mt. Shasta Oil Co. "Ferguson" 1	1904	400	
T. 9 N., R. 3 W., M. D. M.				
*Sec. 6	C. V. Wreden	1937	1024	Cretaceous

SHASTA COUNTY

T. 30 N., R. 5 W., M. D. M.				
Sec. 15	Red Head Oil Co. No. 1	1930	500	Cretaceous

SUTTER COUNTY

T. 16 N., R. 1 W., M. D. M.				
Sec. 36	Tannehill Oil Co. (Maggie Wilson) No. 1	1935	2505	
T. 16 N., R. 1 E., M. D. M.				
Sec. 32	Sutter Butte Oil Co. No. 1	1927	2900	
Sec. 35	Buttes Oilfields Inc. No. "Buttes" 1	1938	2727	(small gas producer)
Sec. 35	Buttes Oilfields Inc. No. 2	1935	7014	(6717 top serpentine. 6951-7014 peridotite.)
T. 15 N., R. 1 E., M. D. M.				
Sec. 1	The Buttes Oilfields Inc. No. 5	1939		
Sec. 2	The Buttes Oilfields Inc. No. 4	1938	5855	Cretaceous (gas producer)
Sec. 11	The Buttes Oilfields Inc. No. 3	1938	6954	Cretaceous (gas producer)

TEHAMA COUNTY

T. 28 N., R. 4 W., M. D. M.				
Sec. 25	Tuscan Oil Co. No. 1	1922	1845	
T. 26 N., R. 4 W., M. D. M.				
Sec. 24	Tehama County Oil Co. and Hooker Dome Oil Co. No. 1	1924	575	
T. 25 N., R. 5 W., M. D. M.				
Sec. 31	Marker Drilling Co. No. 1	1936	4425	Cretaceous
T. 25 N., R. 4 W., M. D. M.				
Sec. 27	Los Chicos Oil Co. "Scharr" No. 1	1936	2650	
T. 25 N., R. 3 W., M. D. M.				
Sec. 35	Richfield Land Co. No. 10	1937	524	
T. 24 N., R. 5 W., M. D. M.				
Sec. 20	Crockett Drilling Syn. Inc. No. 1	1931	1885	Cretaceous
Sec. 20	Crockett Drilling Syn. Inc. No. 3	1936	2101	Cretaceous
T. 24 N., R. 3 W., M. D. M.				
Sec. 14	Apex Drilling Co. "Flood" No. 1	1935	200±	
Sec. 25	Northern Counties Pet. Co. "Ewers-Mooney" No. 1	1936	8253	Cretaceous
T. 2[illegible]				
Sec. 30	E. F. Stella, Trustee, "Johnston" No. 2	1939	3326	
T. 23 N., R. 3 W., M. D. M.				
Sec. 31	Orland Oil Syn. Ltd. "Johnston" No. 1	1934	3780	

YOLO COUNTY

T. 12 N., R. 3 W., M. D. M.				
Sec. 2	Morton S. Martin No. 1	1934	570	
T. 12 N., R. 3 W., M. D. M.				
Sec. 15	Swastika Oil Co.	1923	225	
Sec. 23	Nigger Heaven Dome Oil and Gas Co. "Lee Bow" No. 1	1934	6764	Cretaceous
T. 12 N., R. 1 W., M. D. M.				
Sec. 32	Standard Oil Co. "Peter Cook" No. 1	1937	5009	Cretaceous
T. 11 N., R. 1 W., M. D. M.				
Sec. 36	San Martinez Oil Co. "E. H. Bemmerley" No. 1	1926	6221	Cretaceous
T. 10 N., R. 2 W., M. D. M.				
Sec. 26	Esparto-Lincoln Oilfields Co. No. 1	1930	2380	Ione (Eocene)
T. 10 N., R. 1 E., M. D. M.				
Sec. 27	Yolo Oil Corp. Well No. 1	1925	3150	Cretaceous

* Not shown on map.

4. Taken across six foot bed in twelve foot cut in N.E.¼ of S.W.¼ of Sec. 18, T. 33 N., R. 1 W.

5-8, inclusive—No data on locality or method of sampling.

9. Average sample, run of mine waste dump.

Gas producing tests by Smith Emery Company show that 2.29 cubic feet of gas were obtained per pound of coal. The analysis of gas is as follows:

	Per cent
CO_2	14.8
C_nH_{2n}	2.0
O_2	0.3
CO	16.1
H_2	37.6
CH_4	24.8
N_2	4.4
	100.0

Petroleum and Natural Gas

Oil seeps and natural gas have been known for years to be present in the Cretaceous rocks of this region, and at the present time gas wells are operating at the Marysville Buttes and gas was recently encountered in some quantity near Willows. So far no indications are favorable for petroleum or natural gas in the Tertiary formations of the region. A discussion of the petroleum possibilities may be found in a report by Vander Leck.[53] More recently Trask and Hammar [54] have published a paper concerning the probable source beds for gas and oil in the Mesozoic rocks. They have found that the organic matter is rather uniform throughout the rocks, indicating almost any part of the Knoxville, Shasta, or Chico is as favorable for source beds as any other part. They state, however, that commercial quantities of oil have not been obtained from any of the wells drilled to date, which is a discouraging indication for petroleum. The uniformity of organic content is more encouraging with respect to source beds of gas since the discovery of significant quantities of gas in several wells.

[53] Vander Leck, Lawrence. Petroleum resources of California: Calif. State Mining Bureau, Bull. 89, pp. 49-59, 1921.

[54] Trask, P. D., and Hammar, H. E. Preliminary study of source beds in late Mesozoic rocks on west side of Sacramento Valley, California: Bull. Amer. Assoc. Pet. Geol., vol. 18, pp. 1346-1373, 1934.

GEOLOGY AND OIL POSSIBILITIES OF CALIENTE RANGE, CUYAMA VALLEY, AND CARRIZO PLAIN, CALIFORNIA

By J. E. Eaton *

OUTLINE OF REPORT

ABSTRACT

Caliente Range and environs furnishes the best Miocene record for California. It locally exposes in one homoclinal section 16,600 feet of Tertiary strata, of which some 13,800 feet are Miocene. The Miocene series is almost continuously fossiliferous in the maximum section through the Vaqueros and Temblor, and by combining the faunas of this and other sections an essentially complete faunal succession is obtainable from the horizon of *Turritella inezana* var. *hoffmani* upward to above that of *Astrodapsis tumidus.* The University of California at Los Angeles has at present 110 collections of mollusks and echinoids from 38 consecutive Miocene horizons in the district. Foraminiferal faunas occur in much of the series, and their relation to the macrofaunas can be determined.

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At Caliente Mountain the exposed succession is apparently conformable from its base up through approximately 1,100 feet of Oligocene (?), 4,500 feet of Vaqueros, 4,700 feet of Temblor, and 4,600 feet of Monterey. The unconformity which locally exists elsewhere in the state between the Temblor and the Monterey, causing upper portions of the former and basal portions of the latter to be missing in parts of California, appears to be represented by continuous deposition in much of Caliente Range where there is as much as 1,000 feet of the transitional upper *Baggina robusta* and lower *Turritella carrisaensis* zones partly or wholly absent in various other localities due to unconformity.

Marine members in Caliente Range grade southwest and northeast to nonmarine beds, the marine lower Vaqueros changing to a nonmarine upper Sespe facies in the former, and the marine Monterey to various nonmarine facies in the latter direction. This gradation, in combination with terrestrial vertebrates locally present, allows portions of the Caliente Range marine record to be correlated with the mammalian record elsewhere. Basic flows and sills in the district which prepared for and inaugurated the Monterey type of deposition, and nonmarine facies on the northeast, suggest coincidence of vulcanism with the unconformity between the Temblor and the Monterey which is locally present in some districts, and help to explain changes between these stages.

The district is part of a peculiarly long, deep, and narrow structural trough or graben about 300 miles in length and 20 in width extending from the Santa Cruz region southeast to Caliente Range and then eastward through the San Emigdio district; this trough developed in the Upper Oligocene (?) and sank rapidly throughout the Miocene. The marine record for these times is apparently complete along the axis of the trough, and is locally of great thickness. The particular district seemingly emerged at the close of the Miocene, as subsequent series are thin and nonmarine. The area was profoundly deformed and eroded during the Quaternary revolution, for the existing sediments were steeply tilted, locally overturned and overthrust, and largely removed along the axis of the Caliente Range uplift and borders of the trough. Extensive alluvial fans developed in the late Pleistocene, in part contemporaneous with and fringing broad lakes in Carrizo Plain and northwestern Cuyama Valley; these fans are now being dissected.

Conditions requisite for the occurrence of major oil or gas fields appear to be absent in the exposed areas, because of the deep erosion of the larger anticlines. Small or moderate accumulations of a commercial nature may exist in certain less eroded portions. A few oil seeps are present. Most of the eleven wells drilled for oil in the district have been poorly located as regards structure.

The geological significance of Caliente Range and environs is that its unequaled marine record is located centrally with respect to the Tertiary system in California, and that the grading of bathyal marine to neritic marine, and finally to nonmarine facies provides an association of foraminiferal, molluscan, echinoderm, and mammalian faunas which should help toward solving various problems. Here, in a few miles, nearly every facies of the California Miocene, physical and faunal, marine and continental, is visible in a manner not elsewhere

available. Because of its key features the writer recommends that workers spend at least several weeks in the district before arriving at conclusions on regional Miocene problems of the state.

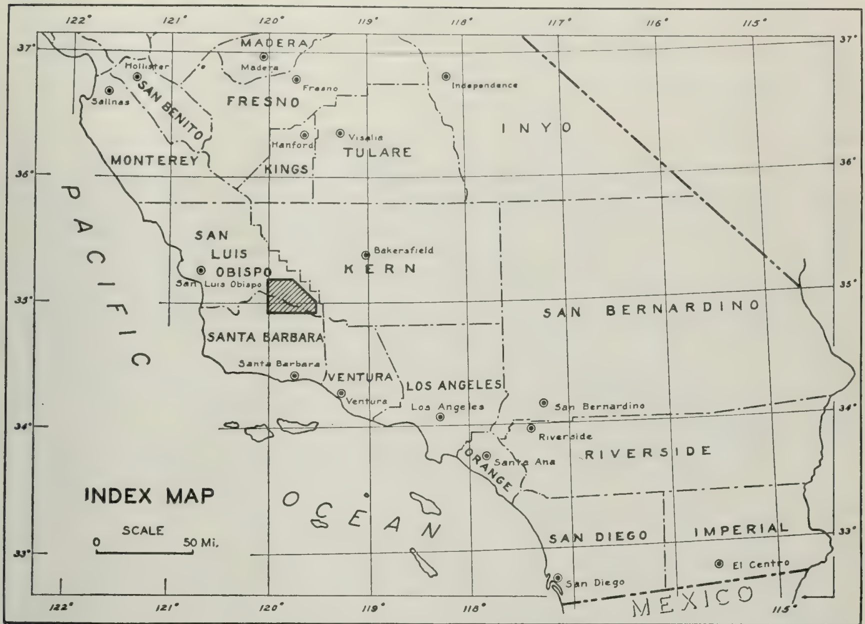

FIG. 1. Index map showing location of area described in this report, *i.e.*: Caliente Range, Cuyama Valley, and southeastern Carrizo Plain.

ACKNOWLEDGMENTS

Notes on the geology of Cuyama Valley were published by Antisell[1] in 1857, and on a diabase exposure in this valley by Fairbanks[2] in 1895. Arnold and Johnson[3] made a reconnaissance of northwestern Carrizo Plain in 1910. In 1916 English[4] published a report on Cuyama Valley, and included portions of the southwestern slope of Caliente Range. In 1936 Reed and Hollister[5] discussed some features and relations of the district as a whole.

The present writer is indebted to U. S. Grant, H. B. Allen, Iliff Anderson, and E. H. Quayle for the determination of macrofaunas, and to P. P. Goudkoff, D. D. Hughes, R. M. Kleinpell, Boris Laiming, and W. D. Rankin for a similar service regarding foraminiferal faunas. J. S. Dougherty and Chester Stock have contributed information on the terrestrial mammals. H. S. Gale, A. I. Gregersen, J. S. Hollister, and R. D. Reed have supplied various data. The photographs are by

[1] Antisell, Thomas, *in* Pacific R.R. reports: U. S. War Dept., vol. 7, pt. 2 (1857), pp. 53-57.

[2] Fairbanks, H. W., Analcite diabase in San Luis Obispo County, Calif.: Univ. Calif. Pub. Bull. Dept. Geol., vol. 1, no. 9 (1895), pp. 273-300.

[3] Arnold, Ralph, and Johnson, H. R., McKittrick-Sunset oil region, Calif.: U. S. Geol. Survey Bull, 406 (1910), pp. 73, 202-03.

[4] English, W. A., Geology and oil prospects of Cuyama Valley, Calif.: U. S. Geol. Survey Bull. 621-M (1916).

[5] Reed, R. D., and Hollister, J. S., Structural evolution of Southern California: Amer. Assoc. Petrol. Geol., Tulsa (1936), pp. 75-85.

Grant, Allen, and Anderson. Headquarters and other assistance were furnished by H. P. Wells and family in Carrizo Plain, and by Mrs. F. M. Richardson and Mr. and Mrs. A. W. Jones in Cuyama Valley.

The following sketch is a brief summary of work accomplished at intervals over a period of eleven years by the writer and various associates. A more detailed report by the author, U. S. Grant, and H. B. Allen on the stratigraphy, structure, and paleontology of the district is in manuscript.

STRUCTURAL HISTORY

The general district discussed seems to reveal no evidence for a local trough in Cretaceous and Eocene times, it having apparently been only a part of the wide area of Cretaceous deposition, and beds of definite Eocene age, though they bound Cuyama Valley on the southeast and possibly occur beneath parts of the valley at depth, have so far not been located here. The feature that the Lower Miocene rests depositionally on the Cretaceous (?) over wide areas with a discordance of 30 to 50 degrees in dip, and as much in strike, suggests that during parts of the missing record the district was a positive area lying between negative areas on the northeast and southwest.

In or about Middle Oligocene time the foregoing structural relation was reversed. The district then became the pivotal part of a long, narrow trough or graben which entered it from the northwest, and, forking where Caliente Range now stands, sent a branch almost due east through the San Emigdio district. Where this trough connected with the sea is not certainly known. The circumstance that in the central channel its Oligocene (?) and Lower Miocene strata are persistently marine, whereas equivalent beds which bound it on the south and west are nonmarine, favors a northwest connection with the sea. Such a course can be traced, intermittently, northwest to the type San Lorenzo north of Monterey Bay, but the record is fragmental between King City and that district due to alluvium and profound post-Miocene deformation and erosion. In this latter, dimmer stretch, the occurrence of isolated patches of the older Miocene several thousand feet in thickness faulted down between igneous and metamorphic masses suggests that during much or all of the Miocene the Caliente trough struck northwesterly to the sea. The persistence of such a long, straight, and deep trench throughout Miocene time seems unexplainable except by a persistently active parent fault.

The Caliente trough is structurally somewhat similar to the much younger Priest Valley trough of Pliocene and lower Pleistocene time, suggesting that the mechanics of both were similar. The latter trough strikes along the northeast side of Reed's Salinia,[6] and the former along its southwest side, the crystalline nature of this granitic backbone being favorable for the occurrence of long, narrow grabens parallel with it.

Throughout Upper Oligocene (?) and all of Miocene time the Caliente trough sank rapidly, remaining a persistent marine channel. The San Emigdio region east of Caliente Range, and the La Panza, southwestern Salinas Valley, and Monterey-Santa Cruz areas northwest of this range were then apparently parts of one narrow channel.

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[6] Reed, R. D., Geology of California: Amer. Assoc. Petrol. Geol., Tulsa (1933). Reed, R. D., and Hollister, J. S., *loc. cit.*

All have a similar Upper Oligocene (?) and Miocene marine succession. The thickest and most persistently fossiliferous Miocene sediments seemingly occur in the extremely depressed Caliente Range portion of the trough (Plate IV) near its fork.

In the Upper Oligocene (?) and very earliest Miocene the Caliente trough (Santa Cruz district to the San Emigdio foothills) seems to have been the only marine inlet deeply penetrating what is now California, but during the Vaqueros stage the marine waters transgressed farther, resulting in a network of waterways [7] and additional inlets, and causing parts of the trough to become only a more rapidly subsiding portion of wider seas during the balance of Vaqueros, and all of Temblor and Monterey time. The axial part resisted the wide regression at the close of the Temblor, thus acquiring a thousand or so feet of Temblor-Monterey transition strata which are partly absent elsewhere. Abnormal subsidence of the trough ended after the *Valvulineria californica* zone sequence was deposited, this zone being only about twice average, and all subsequent zones of less than average, thickness for the state. At the close of the Miocene the portion shown in Plate IV became emergent, and, except for some nonmarine deposition of Pliocene (?) and late Pleistocene age, has remained so to the present, undergoing extreme deformation and deep erosion during the Quaternary revolution.

STRATIGRAPHY

Nomenclature.—Coastal California differs from most other marine provinces of the United States in the feature that instead of having broad sheets of stratified deposits laid down in epeiric seas its Cenozoic strata were deposited in a network of bays and straits on a relatively narrow shelf between highlands and the abyss. Mountainous, irregular peninsulas divided this narrow shelf into isolated marine basins or groups of basins, and cause the strata to lens, ofttimes in a mile or two basinward, from conglomerate to clay. Extreme Pleistocene degradation further isolated different textural groupings, with the result that while characteristic average aspects of the sediments deposited during a major stage tend to be traceable almost state-wide, the actual formations *sensu stricto* comprise a practically innumerable group of narrow textural lenses and remnants of lenses which average two or three miles in width and twenty or thirty in length. It has been estimated that due to this extreme lensing approximately 500 formation names would be required if the Tertiary cartographic units of California were to be separately designated in the manner of the eastern and central United States. To divide California Cenozoic deposits into hundreds of strict formations that disappear one into the other in a few miles is not practical.

Prior to the Twentieth Century separate names were prevailingly used for the everchanging wedges. Early in this century it was perceived that to continue this practice would soon result in intolerable confusion. As a result, faunal groupings were ascertained, the names of about a dozen local Cenozoic formations having priority were

[7] See Loel, Wayne, and Corey, W. H., The Vaqueros formation, lower Miocene of California: Univ. Calif. Pub. Bull. Dept. Geol., vol. 22, no. 3 (1932), map 1. (Present data indicate that the Vaqueros Gulf and the Santa Cruz Bay of this map were connected.)

applied to these, and the resulting stages were carried from basin to basin regardless of the innumerable physical facies. Errors were made and still exist, but the choice was between a standard column and chaos; between a practical system that describes the ever changing local facies of a dozen stages, and several hundred intergrading named wedges with neccessarily assumed boundaries whose number alone would defeat correlation. When a geologist in California uses the marine terms Martinez, Meganos, Domengine, Tejon, Vaqueros, Temblor, Monterey, Briones, Cierbo, Neroly, Jacalitos, Etchegoin, San Diego, Santa Barbara, or San Pedro away from their types he does not refer to a conventional formation but to a stage or substage. He is referring to sediments, laid down during a time horizon, which tend to have a broad, state-wide similarity of average aspect, but which comprise from place to place perhaps half a hundred actual formations.

A formation is properly a physical facies or rhythmic group of facies over the area that is more or less definitely traceable. When an originally local term comes to designate in general usage a major faunal horizon regardless of physical facies or continuity of beds it becomes a stage, and facies descriptions are no longer applicable. For instance, strandward horizons of the Monterey "shale" are now indicated to contain more coarse material than does the entire Vaqueros "sandstone," the suffixes having been originally applied to local facies.

The Miocene terms Vaqueros, Temblor, and Monterey, originally applied to more or less local facies, have been used for a generation in the sense of time horizons. Long usage has established them as designating all marine sediments of the California province, regardless of facies, that carry faunal assemblages characteristic of the original type. They represent the three largest natural divisions of the California Miocene. Each of these faunal stages, however, though comprised of an almost infinite number of intergrading physical facies, coincides over most of coastal California with a more or less regionally characteristic average type of deposition. The practice of referring to them as formations when a time horizon is actually meant has therefore been prevalent. No serious error is involved in such a usage, because it has been understood that the tendency for each faunal stage to coincide with a characteristic average type of deposition, and not the aspect of local wedges, is the meaning intended. However, it is to be noted that the proof is faunal, and that the proper usage is stage.

In the present paper marine sequences of Caliente trough yielding adequate faunas are described as areally changing facies of standard stages and substages, no attempt being made to erect formations in a series that is a continual gradation.

Variations in thickness.—Caliente trough was apparently a narrow synclinal graben averaging about 20 miles wide and 300 miles long during its time of abnormal subsidence, this referring to the structural trough proper. Post-Miocene deformation has reduced its average width to two-thirds or less of that formerly existing. The subsidence, whatever its cause may have been, involved folding along a synclinal axis that was not far from the center of the trough in and near the portion shown on Plate IV, a succession locally 16,600 feet thick along this axis thinning southwest and northeast in a few miles to a small fraction of this thickness without apparent unconformity

except in strandward upper parts. Extreme change of thickness in conformable successions, laterally amounting to several hundred per cent in a few miles, is a feature of the district. Both flanks of successions are not always computable in a single area, but when data from the San Emigdio, Caliente Range, La Panza, Salinas Valley, and Santa Cruz districts are combined, downwarping along a synclinal axis, or more correctly a connected series of synclinal axes arranged en échelon, is apparent. There are also undulating, lesser changes in thickness longitudinally.

Cretaceous (?).—Dark greenish silt and thin to heavy-bedded sandstone many thousand feet in thickness which weathers a dark color bounds Cuyama Valley on the southwest, west, and northwest. Its age, older than that of the Caliente trough, is unknown.

Eocene.—The Eocene series, which is well developed in the San Emigdio portion of the trough and south of Cuyama Valley, is not certainly exposed in the district discussed, but may be locally present in the central channel at depth.

Oligocene (?).—About 1,100 feet of dark, chocolate to black silt almost devoid of prominent sandstones outcrops at the core of the Caliente Mountain anticline. It has so far yielded no fossils. Similar silt, with some medium to heavy-bedded gray to white sandstone which increases toward the base, outcrops beneath the Vaqueros at the southeast end of the Caliente Range to a thickness of 1,500 or more feet, basal strata contain poorly preserved foraminifers as yet undetermined. Since this series is seemingly conformable with the overlying Vaqueros it is inferentially Oligocene, and a marine equivalent of the continental middle Sespe beds, but its age is uncertain. Its base is nowhere exposed in the district.

Vaqueros (Lower Miocene).—Resting with apparent conformity on the dark silt at the core of the Caliente Mountain anticline, and continuously exposed upward to and beyond Caliente Peak (Fig. 2), is 4,500 feet of (basinward) marine Vaqueros. The lower 1,000 feet is composed of alternating thick bands of dark green silty sand carrying thin finer-grained fossiliferous layers, and coarse, pebbly gray sandstone. Above this is about 700 feet of dark green silty sand with occasional thinner sandstones. In the upper 2,800 feet heavy-bedded sandstone is dominant, the included silty sands becoming minor upward. The formation as a whole becomes lighter colored and less massive upward for about 3,300 feet (Fig. 3). At this point occurs a regionally prominent 150-foot *Ostrea-Pecten miguelensis* zone, above which are several hundred feet of coarse white sandstone (Fig. 4) with finer sand partings (uppermost true Vaqueros), followed by several hundred feet of submassive gray sandstone and buff sand (Vaqueros-Temblor transition zone). The entire Vaqueros, which weathers a rusty gray, is here fossiliferous at frequent intervals. The lower half yields almost exclusively Vaqueros species of mollusks. In the upper half some Temblor forms are also present. These latter become prominent in the uppermost several hundred feet (transition zone), at the top of which Vaqueros guide fossils disappear. The range of *Turritella ocoyana ss* overlaps (basinward only), the range of *T. inezana ss* 1,900 feet. The two species have not been observed to overlap strandward.

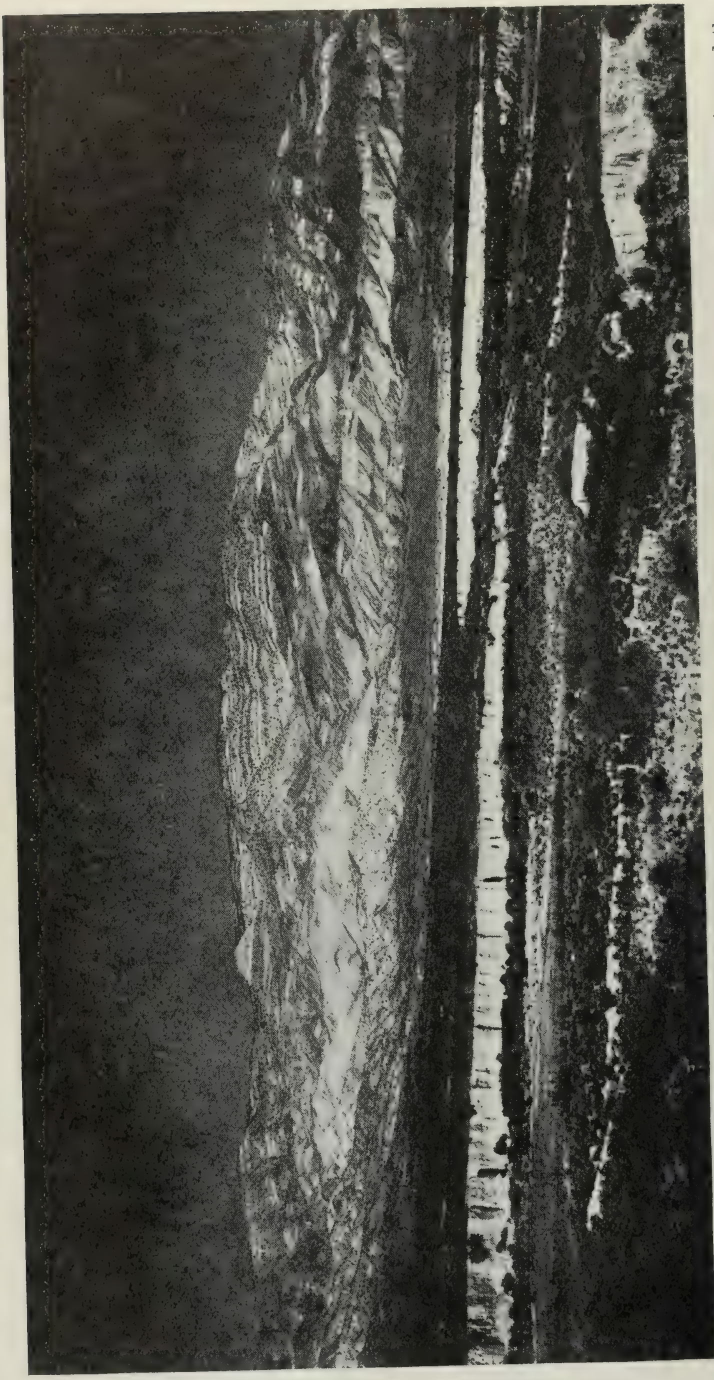

Fig. 2. Caliente Mountain, looking northeast across Cuyama River. Banded Vaqueros of the mountain proper is thrust (toward the camera) over light-colored foothills of vertical or overturned Monterey. The crest line of these foothills, sloping gently downward to the right, approximates the trace of the main thrust. At Scarp Canyon (right) the Temblor is almost entirely cut out. It is about half emergent at Pinnacle Canyon (left).

FIG. 3. Caliente scarp, looking northwest across Scarp Canyon. Near the lower left corner is dark Oligocene(?) silt. The sandstone and silt section above this exposes the main body of the Vaqueros. Uppermost and transitional parts of this stage are not shown in the photograph. The light-colored double horizon at the fog-shrouded crest of Caliente Mountain is the "Key White" sandstone, for which see Fig. 4.

Fig. 4. Detail in upper Vaqueros at top of Caliente scarp. The coarse, cavernous horizon is the "Key White" sandstone. Below this is the *Ostrea—Pecten miguelensis* zone, with the *Ostrea vaquerosensis* zone some distance above. This sandstone, in combination with fossiliferous reefs immediately below it, forms a prominent marker over much of the Caliente Mountain region. The Vaqueros-Temblor transition zone is stratigraphically higher than the summit strata shown.

According to U. S. Grant, ecological aspects are suggested by the feature that, in the general district, the strandward (warmer water?) upper Vaqueros yields a strictly Vaqueros assemblage, whereas this horizon basinward (cooler water?) yields a mixture of Vaqueros and Temblor forms. For example, in the upper Vaqueros the characteristic Vaqueros forms *Pecten magnolia* and *Turritella inezana ss* are common strandward but are rare basinward, whereas the Temblor forms *Turritella ocoyana ss, T. ocoyana* var. *bosei,* and *Echinarachnius norrisi* have not been found strandward but are abundant basinward associated with Vaqueros guides. In this connection it is to be emphasized that the basinward faunal assemblage mentioned is not Temblor, but is characteristic upper Vaqueros with a Temblor admixture. Outside of Caliente trough such mixed assemblages basinward have so far been reported only from seaward portals of the Santa Ana and Santa Barbara embayments, the exposed upper Vaqueros elsewhere being almost universally a strandward deposit yielding a consistently Vaqueros fauna. It may be noted in passing that the form *Turritella inezana* var. *hoffmani,* not known from southern California, where the horizon of the basal Vaqueros is nearly everywhere nonmarine, and originally described from the probable seaward entrance to the Caliente trough, occurs at the very base of (4,400 feet down in) the Vaqueros of Caliente Range.

Preliminary data indicate that the Miocene foraminifera were similarly affected by ecologic factors; in the later Miocene, basinward horizons that yield normal assemblages appear to be represented at stratigraphically equivalent but warmer strandward horizons by mixed assemblages which include forms commonly restricted to horizons from one to three zones older.

In the eastern part of Caliente Range two large anticlines expose respectively partial and complete Vaqueros successions similar to that at Caliente Mountain except that these are coarser, only sparingly fossiliferous, and have a maroon member near their middle. Southward and southwestward in Cuyama Valley the lower Vaqueros grades strandward to a red, nonmarine Sespe facies, above which lies the upper Vaqueros, marine throughout the district, with characteristic mollusks.

The Vaqueros of Caliente Range is similar to that in the adjacent La Panza portion of the trough, except that, due apparently to Caliente Range occupying a more offshore, open position, an admixture of Temblor forms appears much earlier, and the Vaqueros is fossiliferous throughout instead of only near its top as at La Panza.

Temblor (Middle Miocene).—Conformably overlying the Vaqueros of Caliente scarp, and forming the northeast flank of Caliente Mountain, are 4,700 feet of Temblor beds, also fossiliferous at frequent intervals. The lower and middle 3,900 feet of the Temblor is here buff weathering coarse to fine sand with local heavy-bedded sandstones and fossiliferous dark brown reefs and large dark brown concretions. The upper 800 feet (Fig. 5) is here chiefly coarse, heavy-bedded gray sandstone. In this upper portion brackish-water and continental beds yielding terrestrial vertebrates appear at intervals in the marine succession, and three flows of basalt, from ten to thirty feet in thickness,

are present a few hundred feet apart at the base, middle, and top of the member.

The lower and middle Temblor coarsen northeasterly to sandstone, and become more silty southwestward. The upper Temblor coarsens northeasterly to pebbly sandstone, and grades southwestward to a silty facies, there acquiring brown reefs and large brown concretions similar to those in the lower and middle Temblor of the maximum section. The basinward Temblor weathers on the whole a buff color which causes it, particularly when viewed from a distance, to appear quite distinct from the rusty-gray weathering of the basinward Vaqueros. This relation is particularly apparent when looking north from Cuyama Valley at sections on the southeast and northwest ends of Caliente Mountain. Far strandward, as in southern Cuyama Valley where the upper Vaqueros tends to be coarsely white and the Temblor gray to buff, the physical aspects are somewhat less distinct.

Ecologic aspects, while present in the true Temblor of the district, are apparently less radical than those in the underlying Vaqueros; presumably in part because the more open, arcuate Temblor sea seemingly lacked the marked contrast between a narrow central channel and a fringe of shallow, warm arms that existed in Vaqueros time as the Caliente embayment progressively transgressed laterally upon lowlands inherited from the Oligocene.

Monterey (Upper Miocene).—In parts of California the Monterey rests unconformably on the Temblor due to a moderate diastrophism which was marked on the edge of basins but almost imperceptible near their centers. In such areas the two stages are usually distinct. The time of maximum unconformity varies slightly from place to place in California. Thus, in the eastern Santa Monica Mountains the upper *Baggina robusta* and *Valvulineria californica* zones are absent. On the southwestern flank of the district herein discussed parts of both the lower and upper *B. robusta* zone are missing; on the southwestern flank of Caliente Range deposition was continuous and entirely marine; on the northeast flank of this range deposition was continuous but the upper *B. robusta* zone is largely continental; and so on. As an average for all basins the time of maximum emergence in California seems to have corresponded with the early part of the upper *Baggina robusta* zone, with the result that this fauna tends to be found, where the unconformity is minor, both below and above this maximum. The upper part of the zone is an horizon of faunal transition between the Temblor and the Monterey, the two faunas intermingling in proportions which vary according to local ecologic conditions, with here one fauna dominating, and there the other. Due to the differing local ecologic factors and slightly different local times for maximum unconformity a Monterey fauna locally begins slightly below the physical break and a Temblor fauna locally persists slightly above it.

Near the center of deep basins deposition was continuous, and all zones are present including the upper *Baggina robusta* (faunal transition). In this transitional horizon the forminiferal fauna is intermediate between those of the Temblor and the Monterey, tending to most resemble the former in shallower, warmer waters, and the latter in deeper, cooler ones. The macrofauna reveals similar relations, Temblor mollusks surviving in warm, protected bays and inlets at the

same time that Monterey forms were appearing in open, cooler waters. The physical aspects are also intermediate, locally most resembling one and locally the other stage, but being in the great majority of cases nearest the Monterey. The transitional nature of the upper part of the *B. robusta* zone has given rise to controversy in western San Joaquin Valley regarding which stage these strata, locally absent due to unconformity, properly belong to. They would appear to not certainly belong to any distinct stage, but to lean here one way, and there another. For example, in deeper, cooler waters as at Carneros Creek the fauna seems most allied to that of the Monterey, whereas in shallower, warmer waters as near Coalinga it seems most allied to that of the Temblor.

Caliente trough presents most phases of the problem, the transitional horizon being represented, as stated, in the continuously deposited section on the northeast flank of Caliente Range by continental facies carrying marine stringers, in the continuously deposited section on the southwest flank of this range by a wholly marine succession, and in strandward portions of Cuyama Valley by a locally variable degree of unconformity whose magnitude ranges from a cutting out of only a middle part of the *Baggina robusta* zone to an absence of this entire zone and also of zones immediately above and below it. The lower part of the *B. robusta* zone yields a purely Temblor molluscan fauna in all areas of the district, in all known districts of California, and apparently represents the uppermost or Button Bed member of the type Temblor. Wherever definitely present in the state it appears to be below the horizon of maximum unconformity. There thus seems to be every good reason for regarding this part as upper Temblor. The upper part of the *Baggina robusta* zone, on the other hand, yields Monterey mollusks basinward and Temblor mollusks strandward; in southeastern Caliente Range the so-called *Turritella ocoyana* fauna, continuous for 4,700 feet, apparently stops either without entering or shortly after entering the transitional horizon, being replaced by *Turritella carrisaensis,* whereas along the warm southern fringe of Cuyama Valley the *T. ocoyana* fauna continues upward, throughout the transitional portion, nearly to the base of the *Valvulineria californica* zone. Thus, in the upper *Baggina robusta* (transition) horizon there is locally either a Temblor, a Monterey, or a mixed faunal assemblage according to local ecologic factors.

In Plate IV upper parts or transitional strata are shown as basal Monterey because over most of the district their fauna leans toward the Monterey, and they are physically like the sediments of this stage and quite unlike those of the true Temblor below. It is to be remembered, however, that these strata locally yield a Temblor molluscan assemblage along warm fringes of the trough, and are really transitional.

The two major faunal overlaps discussed occasioned by locally different ecologic factors, the Vaqueros-Temblor and the Temblor-Monterey, occur at much the same localities in the district. In both, the warm strandward fringe was the habitat of a pure, older type of fauna at the time that a new fauna was appearing basinward in open, cooler, but not necessarily deeper waters at the same horizon. The two overlaps differ in but one observed phenomenon; in the Vaqueros-Temblor relations the physical aspects are in all areas with the older

stage and the older fauna everywhere dominates, whereas in the Temblor-Monterey relations the physical aspects are in most areas with the younger stage and the younger fauna tends to dominate.

As mentioned, the Monterey is apparently conformable on the Temblor in parts of Caliente Range, but southwestward in Cuyama Valley there is a hiatus involving locally an absence of part, and locally all, of the *Baggina robusta* zone due to fringe conditions.

The basic flows and sills closing Temblor time mark the advent of dominantly nonmarine deposition along what is now the northeastern flank of Caliente Range. The so-called *Turritella ocoyana* fauna there largely disappears, and is followed by 1,300 feet of white, pink, and red nonmarine sand and sandstone with interbedded thin marine layers carrying *Turritella carrisaensis.* Near the top of the reddish series is a prominant basalt flow averaging sixty feet in thickness. Above the reddish series are 425 feet of thin-bedded, greenish, ripple-marked sandstone, then 125 feet of maroon sand, followed by 450 feet of fine, white, brackish-water silty sand carrying pearl-colored reefs, this general series apparently being a strandward correlative of the *Valvulineria californica* zone. Still higher are 1,200 feet of coarse salmon and white probably nonmarine sandstone, pebbly toward its base, and then 1,000 feet of fine to medium light sand and greenish silty sand, also seemingly nonmarine. Above this last are continental white, gray, and pink pebbly sands tentatively mapped as Pliocene (?).

On the southwest flank of Caliente Range, on the other hand, the Monterey is wholly marine. Here, well above thick sills following the middle Temblor (*Uvigerinella obesa* zone), grading up from 650 feet of upper Temblor (lower *Baggina robusta* zone) buff and dark sandy silt with brown reefs and sandstones is 1,000 feet of basal Monterey or transitional chocolate clayey and platy silt carrying yellow reefs (upper *Baggina robusta* zone), then 850 feet of *Valvulineria californica* white sand and silt with pale greenish tints and pearl-colored reefs, and finally 550 feet of white and tan sandstone whose lower part is unfossiliferous but whose upper part carries reefs of *Ostrea titan* and other mollusks starting 310 feet above the *Valvulineria californica* zone. A seemingly conformable sequence. It is to be emphasized that only upper parts of the "*Ostrea titan*" bands of the map on Plate IV have yielded *O. titan* (Neroly), lower parts locally yielding *Ostrea bourgeoissi* and Cierbo astrodapses, as is shown in the correlation chart on this plate. Above the *O. titan* reefs is several hundred feet of fine, gray, nonmarine silty sand with a basal conglomerate of reworked blocks of angular Monterey limestone, mapped as Pliocene (?).

Farther southwest, in Cuyama Valley, locally a part of, and locally all of the *Baggina robusta* zone is absent, with here the *Valvulineria californica* zone, and there the *Ostrea titan* or various intermediate zones, locally resting unconformably upon fossiliferous Temblor and Vaqueros. The *O. titan* sands resemble the type Santa Margarita, and are presumably its equivalent. They carry a Neroly macrofauna and are stratigraphically equivalent to an upper horizon of the type Monterey.

Along Bitter Creek in southern Cuyama Valley is about 1,500 feet of white and tan sand, resting upon *Baggina robusta* buff silt, and yielding what is perhaps the finest echinoid succession in California.

FIG. 5. Looking northwest across Cone Canyon, near the boundary between Caliente Mountain and Carrizo Plain. The heavy-bedded sandstone sequence with flows of the "triple basalt" series near its base, middle, and top, is the uppermost 800 feet (lower *Baggina robusta* zone) of the true Temblor, which latter has a total thickness of 4,700 feet on the northeast flank of the mountain. Silty sand well below the heavy-bedded sequence is in the top of the *Uvigerinella obesa* zone. Above the upper flow is glimpsed a portion of the soft, partly continental upper *Baggina robusta* zone in the basal Monterey (transition).

The basal 50 feet of this succession contains a Temblor macrofaunal assemblage which includes *Turritella ocoyana, Pectan andersoni, P. lompocensis?,* and reefs of a four-inch, pentagonal echinoid. Next above is 400 feet of fine to medium sand carrying *Ostrea bourgeoissi* and presumably representing the Briones substage, then 450 feet of fine to coarse white and tan sand yielding *O. bourgeoissi* and Cierbo astrodapses, then 600 feet of fine to coarse white sand carrying *Ostrea titan* and Neroly astrodapses. Conformably above this 1,500-foot echinoid succession is several hundred feet of siliceous and white clay shale with interbedded fine powdery sands containing *O. titan* and other mollusks. Farther east, what appears to be this latter horizon carries *O. titan* and *Turritella carrisaensis.*

The indicated Briones or lower *Ostrea bourgeoissi* zone part of the Bitter Creek succession occupies the stratigraphic position of the *Valvulineria californica* zone of Caliente Range. The Neroly part of the Bitter Creek succession correlates faunally and lithologically with the *Ostrea titan* zone of Caliente Range. The intervening Cierbo or upper *O. bourgeoissi* part at Bitter Creek is similar to, and seemingly represents, the equivalent thickness of barren sand between the *V. californica* and *O. titan* zones at Caliente Range. The fauna of the Bitter Creek upper Miocene echinoid succession, which has been collected thoroughly and in detail, will be the subject of a forthcoming separate paper by Prof. U. S. Grant.

TABLE I

WHITEROCK BLUFF	SECTION CANYON, NE. OF MORALES FAULT		SULPHUR AND GOAT SPRINGS	CONE CANYON VICINITY	
240′ wh. and pink sd. *Ostrea titan.*	(Faulted out.)				
310′ coarse wh. and tan sd.	300′ coarse wh. and br. sd.		(Eroded)	1,200′ coarse salmon to wh., pebbly s.s.	
Valvulineria calif. 600′ fissile diatomite. Pearl reefs grading down to yellow.	*Valv. californica.* 850′ fine wh. to pale green sd. and silt. Pearl reefs grading down to yellow.		Wh. sd., silty near top.	1,000′ fine wh. gypsiferous silty sd. overlying greenish s.s. Pearl and yellow reefs.	
Baggina rob., upper. 200′ chocolate clayey and platy shale. Yellow reefs.	*Bag. robusta, upper.* 1,000′ chocolate clayey and platy shale. Yellow reefs.		1,100′ red, pink, and wh. nonmarine s.s., with marine layers.	Red s.s. 1,300′——Flow—— Red, pink, and wh. nonmarine s.s. with marine layers.	*Turritella carrisaensis*
(Unexposed) MONTEREY					
TEMBLOR	*Bag. robusta, lower.* 650′ buff and dark sandy shale, and s.s. Brown reefs. ——Sill——		——Flow—— *Bag. rob., lower.* 700′ buff sandy silt and s.s. Brown conc. reefs.	——Flow—— Lavender pebbly. 800′ Buff conc. sd. Gray to wh. s.s. ——Flow—— Gray s.s., buff sd. ——Flow——	"*Turritella ocoyana fauna*"
	MAIN CANYON Sills in silt and s.s.	PINNACLE CANYON (Cut out by Caliente Mountain thrust fault.)	Silt and s.s. with thick brown reefs.	*Uvigerinella obesa.* S.s. and silty sd. Brown reefs and concretions.	
	U. obesa. Sd. and silt. Br. reefs.		S.s. and sd. with brown reefs.	S.s. and sd. with brown reefs.	
	Silt and s.s.		*Plecto. miocenica.* S.s. and silt.	S.s. and silty sd.	

Table I indicates some relations between the Monterey and the upper Temblor in four parts of Caliente Range from southwest to northeast; from finer to coarser and thicker deposition. Note that the lower part of the *Baggina robusta* zone is physically gradational into the upper part of this zone in Section Canyon, and that this lower part yields a *Turritella ocoyana* fauna and the upper part *Turritella carrisaensis* in the Cone Canyon area. The first locality illustrates the depositional and foraminiferal gradation in deeper, and the second the depositional and macrofaunal gradation in shallower, waters.

Pliocene (?).—In the Morales syncline southwest, and in the large syncline northeast of Caliente Mountain, highly deformed nonmarine white, gray, and pink impure silty and pebbly sands of unknown age occur above the *Ostrea titan* zone of the Monterey.[8] They are apparently unconformable on the Monterey in the Morales syncline, where they have a basal conglomerate containing reworked angular blocks of Monterey limestone. They have the gradational bedding and drab coloring of finer textures common in the Pliocene of California, but in an absence of fossils (they contain worn, redeposited Miocene oysters) their age is uncertain. In Carrizo Plain, where the uppermost Miocene is also continental, the contact has not been definitely located. The contact, there indefinite, has been drawn at the top of the highest volcanic outcrop observed. Scattered outcrops of variegated, steeply dipping Pliocene (?) continental beds occur in southern and far western parts of Cuyama Valley above continental beds in the uppermost Miocene, and below gently dipping Quaternary fans.

Lake deposits (late Pleistocene).—Several hundred feet of flat, laminated lacustrine beds in western Cuyama Valley suggest that in late Pleistocene time a broad fresh-water lake existed there. The deposits include three horizontal members composed upward respectively of pinkish, gray, and dark silty clay. In Carrizo Plain the present Soda Lake is the remnant of a larger lake which presumably covered most of that area in the late Pleistocene.

Quaternary fans.—Partly dissected alluvial fans cover much of Cuyama Valley southwest of Cuyama River, these comprising an older series (essentially the Cuyama formation of English) earlier than and partly contemporaneous with the lake deposits, and a younger series later than the lake. Other, gentler fans are presumably present in thickness under the lake-smoothed surface of Carrizo Plain.

PRESENT STRUCTURE

General.—The general district is at present a highly deformed region with prevailingly steep, deeply eroded anticlines that are usually accompanied by faulting, and, in Caliente Range, are locally overthrust southwestward toward Cuyama Valley. Carrizo Plain is heavily faulted along both flanks in and northwest of the territory shown on the accompanying map, and flat central portions may contain other faults beneath the thick alluvial cover. In western Cuyama Valley the

[8] These are not the Cuyama formation of English, which is largely a gently dipping alluvial fan deposit of late Pleistocene age, but are the upper half of his type Morales: "* * * shale pebbles * * * a few large oyster shells that are secondary * * *" (*loc. cit.*, p. 203).

Cretaceous (?) system is strongly deformed, but the comparative thinness of the Tertiary cover there causes this latter system to locally have a relatively gentle attitude. Southern edges of the valley expose tightly compressed, fractured folds. The structure of much of the broad upper valley is concealed by alluvium and alluvial fans.

Caliente Mountain thrust fault.—The thrust fault along the southwestern foot of Caliente Mountain illustrates all stages of thrusting from an overturning anticline, through an initial break, and then on to a major thrust sheet. It presents the best locality for studying the mechanics of thrusting that the writer has so far observed.

Caliente Range is composed of a number of anticlines arranged en échelon which apparently formed slightly southwest of the axis of maximum Tertiary subsidence and deposition. These anticlines have been strongly thrust southwestward, by pressure from the northeast, toward Cuyama Valley. The resistance exerted by the consolidated Cretaceous (?) rocks beneath the relatively thin Tertiary cover of Cuyama Valley has caused the anticlines to overturn and locally break along their southwestern flanks, with the result that a series of thrust faults arranged en échelon has developed. This local series is but a small part of the great thrust arcs in Southern California that extend for fifty miles south and southwest from the bending San Andreas rift.

The Caliente Mountain thrust fault is opposite the deepest part of the Caliente trough, the feature that it is the largest of the local thrusts being seemingly due to this circumstance. The initial break in the overturning Caliente Mountain anticline is indicated to have occurred a short distance southwest of its present high point; that is, slightly down the overturning southwestern flank. The maximum present throw occurs at this locality. The thrust here cuts out about 3,000 feet of strata, the upper Vaqueros resting, in Scarp Canyon, against the lower part of the *Baggina robusta* zone.

From the focal point in Scarp Canyon, which forms a reëntrant due apparently either to some resistance that determined this point or to a larger slippage and therefore a local relief of pressure there, two arcuate wings curve northwest and southeast (Plate IV), their throws decreasing outward. The throw of the northwest wing declines in the two miles between Scarp and Pinnacle canyons to about 2,000 feet, the upper Vaqueros resting against the *Uvigerinella obesa* zone of the middle Temblor at the latter locality, and dies out completely in another two miles or less. The southeast wing has a more or less sustained throw of about 3,000 feet for a mile and a half, at which distance from Scarp Canyon the lower Temblor almost touches the *Valvulineria californica* zone. The wing then passes under terrace deposits, but is indicated by the mapped relations to die out, on an arcuate course, five or six miles from the focal center.

The strata on both sides of the thrust stand from vertical to overturned throughout its visible course, having practically the same dips on both sides. This latter feature causes the trace of the thrust to be generally inconspicuous, even where it cuts diagonally across the strike, though the convergence of horizons is locally marked. Both the overriding and overridden strata are cut out along the northwestern wing, while along the southeastern wing the overriding strata emerge and slide farther over the overridden flank.

A secondary, lesser, parallel thrust is now forming about half a mile mountainward. At its focal point, also in Scarp Canyon, this secondary thrust is between the lower and upper Vaqueros, and cuts out a middle 1,000 feet of this stage. Northwestward the throw dies rapidly, disappearing within two miles at or near Pinnacle Canyon. Immediately east of Scarp Canyon the trace is somewhat obscured by landslides, but appears to cut into or across the Oligocene (?) dark silt, and then possibly underneath the landslides, the throw becoming negligible in less than a mile. The southeast wing, though shown on Plate IV as a break, is at present little more than a knife-edge overturning fold. Allowing for a computed thirty per cent thinner section on the southwest flank than the northeast flank of the Caliente Mountain anticline, the maximum amount of strata cut out by the combined primary and secondary thrusts totals about 4,000 feet, this maximum being in Scarp Canyon.

Northwest of the Caliente Mountain thrust, the Morales Canyon thrust fault, lying en échelon with and overlapping the former, gradually assumes the task of relieving pressure. The latter thrust increases its throw northwestward, in the direction that the former thrust decreases. Southeast of the Caliente Mountain thrust other thrusts, visible or indicated by overturning to exist along the alluvial edge of Cuyama Valley, lie en échelon and relieve the strain.

PROSPECTS FOR THE OCCURRENCE OF OIL AND GAS IN COMMERCIAL AMOUNTS

Eleven wells seeking oil or gas have been drilled in the area covered by Plate IV, and several more in Carizzo Plain northwest of this map, so far without success. Few of these have been located favorably as regards structure.

Conditions in the district do not appear conducive toward the occurrence of major pools of oil or gas, there being a seeming absence of large anticlines having sealed reservoir beds above a generative series. It is possible, however, that small or moderate accumulations of a commercial nature may ultimately be found. Two oil seeps have been observed by the writer; one in basal Temblor strata of Caliente Range about two and a half miles north of Cuyama Ranch headquarters, and the other in Monterey strata in the bed of Cuyama River near Whiterock Bluff. Arnold and Johnson [9] report an outcrop of oil sand in sections 14 and 23, T. 29 S., R. 17 E., M. D. B. & M., northwestern Carrizo Plain.

The problem in the district is not to find closed anticlines, for many occur, but to find such that are not so deeply eroded and fractured that any oil and gas once contained has escaped. Of the three largest anticlines in Caliente Range, that at Caliente Mountain is domal but is eroded into the Oligocene (?) and thrust southwestward over most of the Temblor, another farther east is domal but eroded half way down through the Vaqueros, and the easternmost anticline is eroded deep into the Oligocene (?), is faulted on both flanks, and closure is not certain.

[9] *Op. cit.*, p. 215.

Southeastern Carrizo Plain is less eroded, but is indicated to be badly fractured. Northwestern parts of this plain are somewhat but less broken, and have a number of closed anticlines in and northwest of Plate IV which retain an appreciable thickness of the original Miocene cover.

Western Cuyama Valley is deeply eroded. Southern edges of this valley are strongly compressed and faulted. The stratigraphy and structure of broad eastern parts having an alluvial cover is unknown.

BROAD UNITIES

Though nearly all Miocene horizons in the district grade from locally fine to locally coarse textures, from locally marine to brackish to continental beds, and in so doing duplicate most of the sedimentary facies of California, each of the three major divisions, Vaqueros, Temblor, and Monterey, retains in the aggregate a peculiar unity despite the extreme range in facies. Except near the coarse strands, here, as in most other marine districts of California, with regional work the field geologist comes to recognize in each division an average aspect that differentiates it, broadly viewed, from the others. The regional worker is struck by the feature that characteristic aspects in any of these divisions are more apt to resemble aspects at equivalent time horizons in other basins a hundred miles away than those in a division here immediately overlying or underlying it.

The district yields the best macrofaunal sequence for the Miocene as a whole that is known in California, but if faunas were entirely absent a competent stratigrapher mapping carefully, in detail, and pondering the cause of facies changes would probably segregate the three major divisions, and carry them, notwithstanding the extreme range in texture, throughout the district with little error; errors would largely be confined to several hundred feet in the Vaqueros-Temblor and Temblor-Monterey transition zones. Such considerations tend to show that the physical and faunal features, while revealing extreme variation, in the aggregate followed basic controls that operated over most of the state.

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DEPARTMENT OF NATURAL RESOURCES

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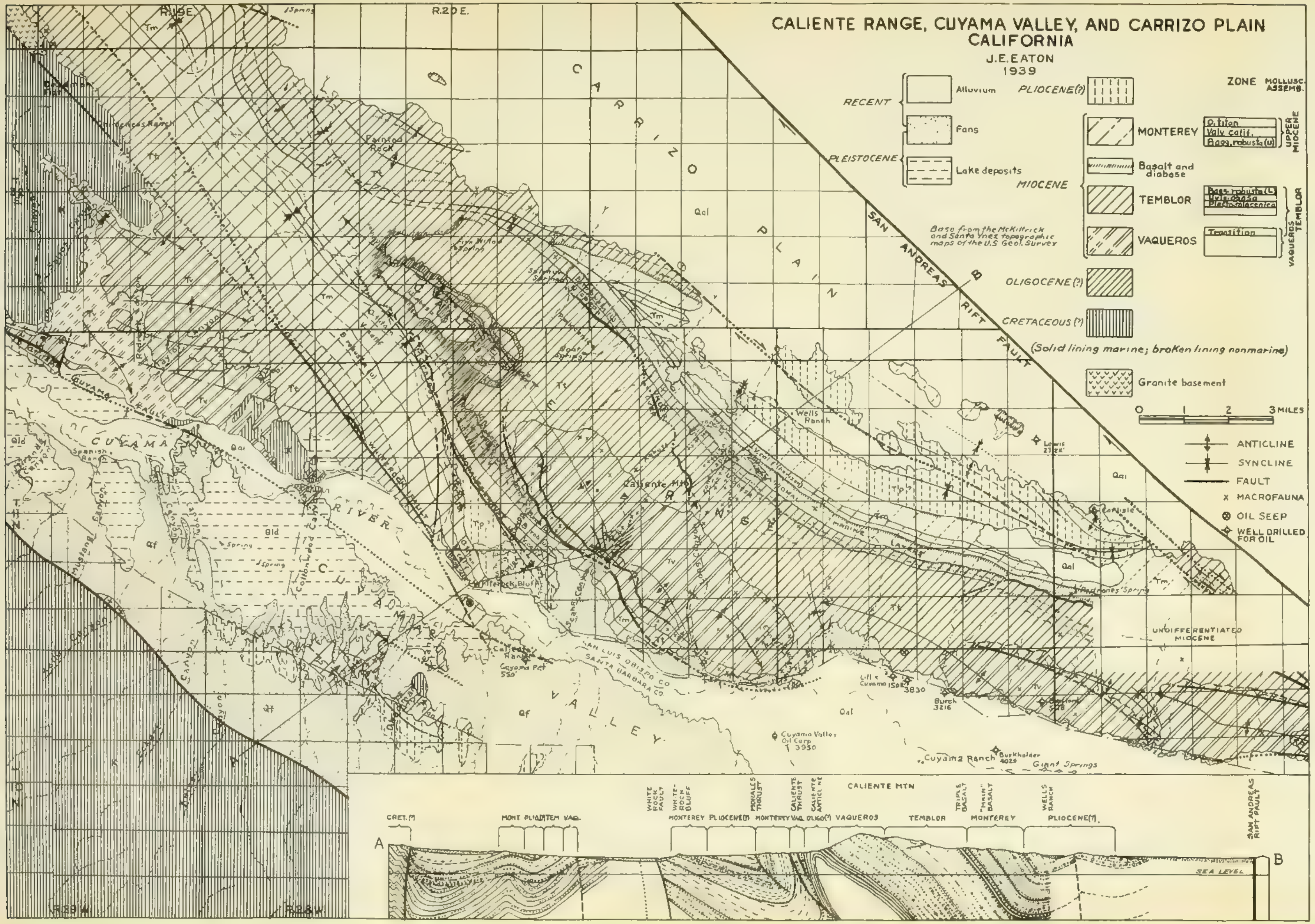
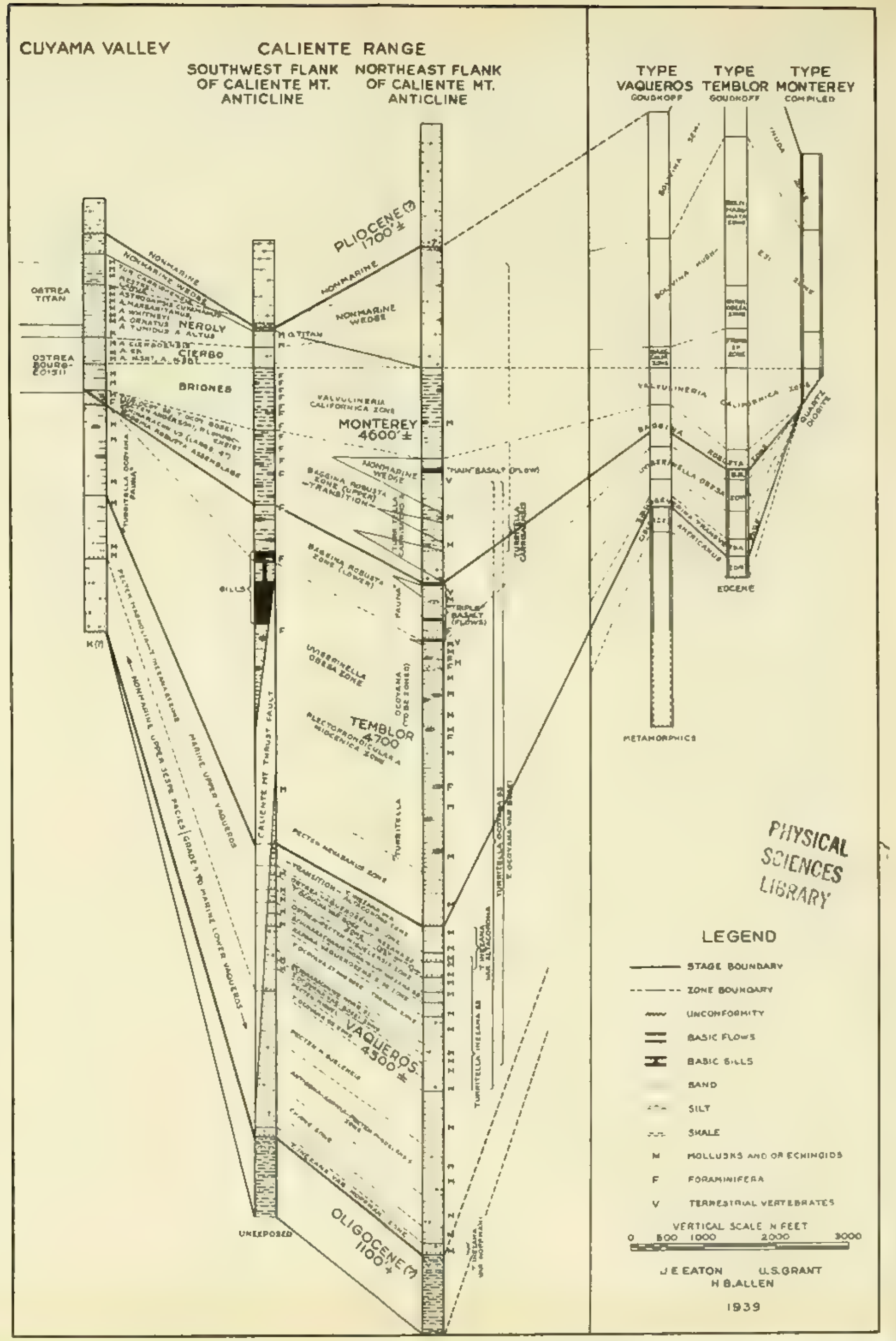
PLATE IV





BIBLIOGRAPHY OF THE GEOLOGY AND MINERAL RESOURCES OF CALIFORNIA

FOR THE YEAR 1937

(Supplementing Bulletins 104 and 115 of the Division of Mines)

PREPARED UNDER THE DIRECTION OF SOLON SHEDD*

CONTENTS

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INTRODUCTION

This bibliography represents a continuation of Bulletins 104 and 115 of the Division of Mines. Bulletin 104 carries the work from the very beginning of publications on California geology to the end of 1930, while Bulletin 115 covers the years 1931 to 1936, inclusive. The present bibliography, though intended to cover publications of only one year, 1937, includes also some references which were omitted in the earlier bulletins.

The same plan is followed and the same abbreviations are used as may be found in Bulletins 104 and 115. The index has been prepared, as before, from the information given in the titles. No attempt has been made to annotate or classify the publications according to the matter discussed within the texts.

It is the intention of the Geologic Branch to keep up this bibliographic work and to publish it annually. We have always received much help from a large number of persons interested in the geology of California, and for this help we are very grateful. We solicit further help and we wish to be kept informed as to new publications dealing with California, its geology and mineral resources.

Also, any corrections which should be made on our published reports will be welcome. It may be of special interest to research workers to know that the Geologic Branch from time to time issues a mimeographed list of "Geologic projects under way relating to California." This list, since it deals with papers not yet completed, is not released for publication nor widespread distribution. Its purpose is to keep research workers informed of new projects under way and thus eliminate duplications and conflict of endeavors. The last list, prepared May 1, 1939, indicates that much research is being done. Though much abbreviated, the list is seven pages long, single-spaced and typed on legal-sized pages. In order to bring this list up-to-date, the Geologic Branch wishes to be kept informed of new projects which may now be under way.

Olaf P. Jenkins, Chief Geologist.

ABBREVIATIONS USED

Abst ---abstract
Ac Sc, C R------------------------Acadamie des sciences, Paris. Comptes rendus
Am As Petroleum G, B, Guide Book-------------American Association of Petroleum Geologists, Bulletin, Guide Book
Am Ceramic Soc, B----------------------------American Ceramic Society, Bulletin
Am Geog Soc, Sp Pub-----------American Geographical Society, Special Publication
Am Geop Union, Tr----------------------American Geophysical Union, Transactions
Am I M Eng Tr------American Institute of Mining and Metallurgical Engineers, Transactions
Am Inst Petroleum Drilling & Production Practice----------American Institution of Petroleum, Drilling and Production Practice
Am J Sc--American Journal of Science
Am Mineralogist ---American Mineralogist
An Bib Ec----------------------------Annotated bibliography of Economic Geology
ann --Annotated
Biol Absts---Biological Abstracts
Cal As Sc, Pr------------------------California Association of Science, Proceedings
Cal Dp Nat Res, Div Mines, M G, J, St Mineralogist Rp---------State of California, Department of Natural Resources, Division of Mines, California Journal of Mines and Geology
Cal Dp Nat Res, Div Oil and Gas, California Oil Fields---------State of California Department of Natural Resources, Division of Oil and Gas, California Oil Fields
Cal Dp Pub Works, Div Water Res, B---------State of California, Department of Public Works, Division Water Resources, Bulletin
Cal Oil World---California Oil World
Cal Univ, Dp G B---------California, University of, Department of Geological Sciences, Bulletin
Carnegie Inst, Wash, Pub----Carnegie Institution of Washington (D. C.) Publication
Chem Industries---Chemical Industries
Chem Met Eng------------------------------Chemical and Metallurgical Engineering
Condor --
Cushman Lab Foram Res, Contr------Contributions from the Cushman Laboratory for Foraminiferal Research
Driller, The ---
Ec G--Economic Geology
Eng M J--Engineering and Mining Journal
Eng News-Rec-------------------------------------- Engineering News-Record
Figs --Figures
G Rundschau---Geologische Rundschau
G Soc Am, B, Pr---------------Geological Society of America, Bulletin, Proceedings
G Zentralblatt-------------------------------Geologishes Zentralblatt. Anzeiger fur Geologie, Petrographie, Paleontologie und verwandte Wissenchaften
Geog Rv---The Geographical Review
illus ---illustrated
incl ---including
Int As Hydrology, B---------------International Association of Hydrology, Bulletin
J G---Journal of Geology
J Mammalogy --Journal of Mammalogy
J Paleontology--Journal of Paleontology
J Sed Petrology--------------------------------Journal of Sedimentary Petrology
M Cong J--Mining Congress Journal
M Metal--Mining and Metallurgy
Madroña ---
Min Absts --Mineral Abstracts
Mineralogist --
N Jb-----------------Neues Jahrbuch fur Mineralogie, Geologie, und Paläeontologie

Nat Ac Sc, Pr---------------------------National Academy of Sciences, Proceedings
Nat Geog Soc Mag---------------------------National Geographic Society Magazine
Nat Res Council---------------------------National Research Council
Oil and Gas J---------------------------Oil and Gas Journal
Oil Weekly ---------------------------
Pacific Mineralogist ---------------------------
Pan Am G---------------------------Pan American Geologist
Petroleum Eng ---------------------------Petroleum Engineer
Petroleum World ---------------------------
Pop Sc Mo---------------------------Popular Science Monthly
pp ---------------------------pages
S Cal Ac Sc, B---------------------------Southern California Academy of Sciences, Bulletin
San Diego Soc N H, Tr---------------------------San Diego Society of Natural History, Transactions
Science n s---------------------------Science, new series
Seism Soc---------------------------Seismological Society
Seism Soc Am, B, Earthquake Notes---------------------------
---------------------------Seismological Society of America, Bulletin, Earthquake Notes
Soc G Belgique, An---------------------------Société Géologique de Belgique, Annales
Southwest Mus Papers---------------------------Southwest Museum (Los Angeles) Papers
U S B M, Dp Commerce, B, Inf Circ, Min Yb, Rp, Invest---United States Bureau of Mines, Department of Commerce, Bulletin, Information Circular, Mineral Yearbook, Report of Investigations
U S Coast S, Sp Pub--United States Coast and Geodetic Survey, Special Publication
U S Dp Agr, Bur Soils, Ser---------------------------
---------------------------United States Department of Agriculture, Bureau of Soils, Series
U S G S, W-S P, P P---------------------------
----United States Geological Survey, Water-Supply Paper, Professional Paper
U S Nat Park Service---------------------------United States National Park Service
Western City---------------------------
Westways ---------------------------
Yosemite Nature Notes---------------------------
Zs Prak G---------------------------Zeitschrift für praktische Geologie

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THE GIANT GOOSE LAKE METEORITE FROM MODOC COUNTY, CALIFORNIA *

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The Giant Goose Lake Meteorite, recovered in Modoc County May 4th and 5th, 1939, is on exhibition in the Astronomy Exhibit of the Golden Gate International Exposition on Treasure Island, along with an excellent exhibit of parts of smaller falls. Never before in the San Francisco Bay area have we had an opportunity to examine in detail such a large and unusual meteorite. One can poke it in the ribs, feel its surface, or study an etched portion, as it lies in state, viewed with awe by thousands who have never before seen a meteorite.

The interesting story of the discovery and recovery of this giant celestial visitor, if more widely known, may stimulate search for other meteorites large and small, of which there must be many, scattered over the plains and mountain slopes of a state with an area as great as that of California. It is surprising that, so far as records show, only nine other meteorites have been found in California.

Of the ten meteorites now recorded as found in California, seven are irons and three are stones. The total weight of the six irons previous to the discovery of the Goose Lake Meteorite is approximately 714 pounds. The years in which these meteorites, no one of which was seen to fall, were recovered is given on Fig. 1. The estimated masses of the other meteorites are as follows:

The *Shingle Springs* iron, which weighed 85 pounds, seems to have been lost after it was studied and described. The *Canyon City,* Trinity County, iron weighed about 19 pounds. It is, I believe, in the Field Museum in Chicago. The *Ivanpah,* sometimes called San Bernardino, originally weighed 128 pounds. It is a splendid specimen and is on exhibition at the State Division of Mines in the Ferry Building, San Francisco. The *Oroville* iron was estimated to have a weight of 54 pounds. It was on exhibition at the California Academy of Sciences in San Francisco before the fire in 1906. It is the opinion of the writer of this article that the iron meteorite of about this weight exhibited at the State Division of Mines, the history of which is obscure though it is labeled *Canyon Diablo,* may be the *Oroville* meteorite. The *Surprise Springs* iron weighing about 3 pounds is in the Field Museum in Chicago. The *Owens Valley,* a splendid specimen of 425 pounds, has found its resting place in the U. S. National Museum in Washington. The small *Muroc* specimens are in the Griffith Observatory, Los Angeles.

The author of this article, speaking upon the subject of meteorites before the Astronomical Society of the Pacific in San Francisco several years ago, using a map of the United States upon which meteorites which have been recovered were shown, emphasized the fact that while California boasted of having the best of everything, in meteorites we were far behind the eastern states. At that time only eight meteorites

* A portion of an illustrated lecture presented before the California Academy of Sciences, San Francisco, September 6, 1939.

had been reported in California, but since then the fragments found near Muroc and Muroc Dry Lake had been recovered, as well as the Goose Lake Meteorite.

We owe our opportunity to handle, and study, and exhibit this meteorite to the fact that three deer hunters from Oakland, Messrs. Joseph Secco, Clarence A. Schmidt, and Ira Iverson, on October 13,

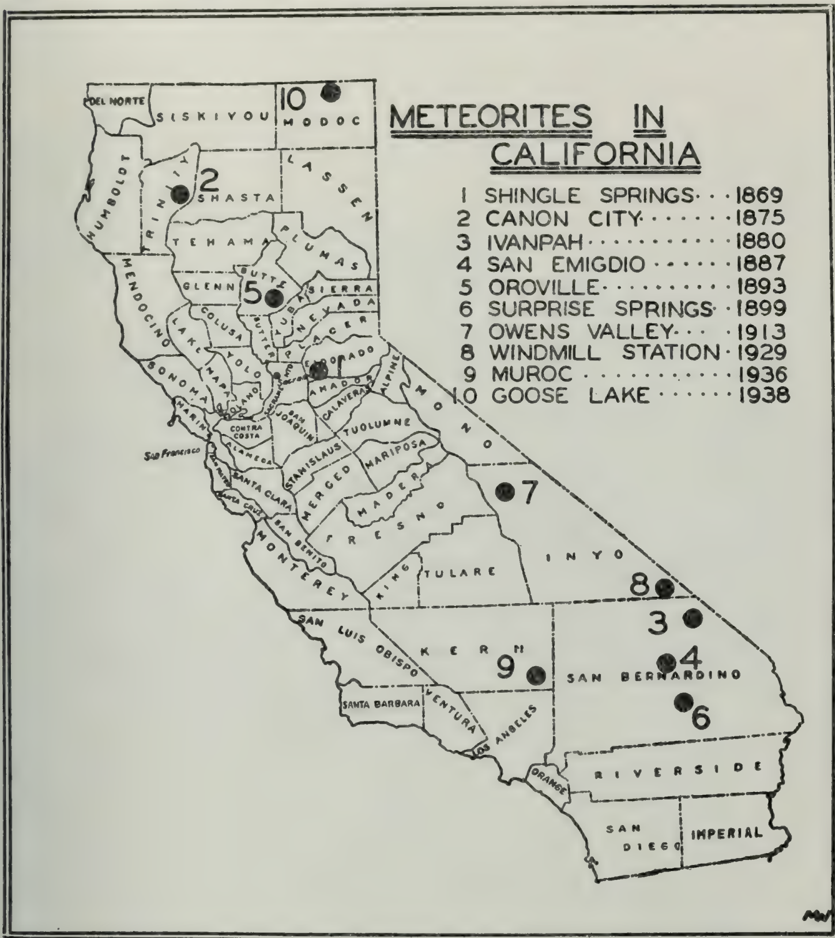

FIG. 1. Outline map of California showing approximate locations where meteorites described in literature have been found, with dates of finding. No meteorites seen to fall in California have been recovered, so far as is known. There must be many undiscovered meteorites scattered over California at the present time.

1938, stumbled upon the mass of rock-like material while roaming over the higher barren portion of the Modoc Lava Beds a few miles west of Goose Lake. That one of the party suspected it was a meteorite is due to education on this subject by Chabot Observatory. A sample was brought back, identified as meteoritic, and in April of this year an expedition was organized to bring out the meteorite.

After it had been relocated among the thousands of lava boulders it was necessary to make a rough survey to determine whether it was

on private property, or in the Modoc National Forest. In this service, Rex Albright, of the U. S. Forest Service Office, in Alturas, rendered assistance.

Having determined that the meteorite lay in a National Forest, the ownership was settled. It belonged by law [1] to the Smithsonian Institution. The first impulse was to let their collectors get it out, for the meteorite was in an area inaccessible except for saddle horses. However, after consultation, it seemed that it might be possible to secure the privilege of exhibiting it at Treasure Island, so telegrams were sent to Washington, and permission was granted.

FIG. 2. Goose Lake Meteorite at Chabot Observatory, May 8, 1939. Meteorite is reversed. The side turned up is the side which rested partially buried in broken lava and soil. The line between the exposed and buried portion can be traced. Lichens are visible on the weathered surfaces.

A small panel truck was secured from Mills College in Oakland, and an expedition under the direction of Dr. H. H. Nininger of the Denver Meteorite Laboratory and the speaker was organized to bring out the meteorite. In this expedition, Dr. F. C. Leonard, and Dr.

[1] Under the Act of Congress, approved June 8, 1906 (34 Stat. 225), historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest situated or found on lands owned or controlled by the United States Government, may not be excavated or removed except by permission of the Department of the United States having jurisdiction over the land involved, and under rules and regulations prescribed by that Department. Such rules are subject to the proviso that "the examinations, excavation and gathering are undertaken for the benefit of reputable museums, universities, colleges, or other recognized scientific or educational institutions, with a view to increasing the knowledge of such objects, and that the gatherings shall be made for permanent preservation in public museums."—Walter W. Bradley, State Mineralogist, Sept. 26, 1939.

Robert W. Webb of the University of California at Los Angeles, as well as Mrs. H. H. Nininger, cooperated.

Help was secured from the ranch of Mr. Everly on the Goose Lake Road some 40 miles from Alturas. Everly and members of his family set aside their ranch work, which was pressing, and used their horses and an old wagon body to get the meteorite through the rough terrain. This took nearly three days. However, when the meteorite was brought to Alturas, it was transferred to the Mills College truck in a few moments by using the derrick on an auto wrecking truck.

There would have been little difficulty in recovering this specimen had it dropped upon the highway, or near it; but as it lay far back on the rough lava flow where the surface had weathered into large boulders, and where no road existed, the work of moving it was tedious.

Iron meteorites usually weigh about 500 lb. to the cubic foot. The dimensions of this mass are 3 ft. 10 in. by 2 ft., and $4\frac{1}{2}$ in. by 1 ft. 8 in. The weight was 2,573 lb. If the holes had been filled in, the weight would have exceeded 3,000 lb. The metal in this meteorite is solid, steel-like, and tough as steel. When hit with a hammer on the edge, the meteorite rang like an anvil, and a moderate blow with an ordinary hammer made no mark on the surface.

FIG. 3. Goose Lake Meteorite lying among the lava boulders of Modoc County. Photographed before meteorite had been disturbed, showing largest side exposed to the weather and wind.

Left to right: Rex Albright, U. S. Forest Service, and Mr. Murphy and Mr. Ake, two ranchers who helped recover the meteorite.—*Photo by Earle G. Linsley, April 30, 1939.*

Lichens had been able to establish themselves on the surface, and there were several solid patches about the size of a silver dollar, and one patch nearly twice this size. This lichen growth caused the meteorite to resemble the lava boulders scattered around in great numbers. From these it differed only slightly in color and in general form, as viewed by a casual observer.

These iron meteorites usually show burnt surfaces or skins. The surface is iron black on pieces which have been known to fall recently. However, when old falls like the Goose Lake Meteorite are found, the surface is a rusty brown. On this meteorite the surface exposed to the weather is almost a mahogany color. Though it feels smooth, as one runs a hand over it, there are tiny granules which may be felt on this polished surface. In the numerous holes the edges turn in, and are sharp and jagged on the inside.

The side which rested on and was partially in the soil has the characteristic appearance of rusty iron, but is smooth and nowhere crumbling in disintegration. The prominent external pits characteristic of iron meteorites were far less numerous on this protected side. On the exposed side the external pittings had developed into holes, many of which were several inches deep; some extended through the specimen. There were no sharp edges or angles on the meteorite. There was no accumulation of rusty pieces on the ground around it. There was no evidence of shattered rocks indicating a recent fall, and there were no skid marks to show that the meteorite had swept along the surface and come to rest where it was found. There was only the slight depression in which it rested, which appeared to be due in part to wind erosion as the air currents had eddied about it. A marmot seeking a bombproof shelter had made a home under it.

The questions which have been asked: the length of time the meteorite had lain among the lava boulders; whether it could have fallen on ice; whether it was of the same character as the great Willamette Meteorite of Oregon; whether other pieces are to be expected, are all interesting, but beyond the ability of this writer to answer.

Our hope is that this discovery will result in searches for other meteorites, and that these searches will be productive, so that much may be added to our knowledge of these interesting celestial visitors.

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SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

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COSTS OF TRUCKING AND PACKING ORE IN WESTERN GOLD-MINING DISTRICTS [1]

By E. D. GARDNER [2]

INTRODUCTION

Ore and concentrate are transported on the surface at western mining districts by (1) railroads, (2) surface trams, (3) aerial trams, (4) trucks, and (5) wagons, and (6) on the backs of animals.

The daily and ultimate tonnage to be moved is the principal factor governing the selection of the method of transportation. Railroads are preferred when large tonnages are to be hauled over relatively long distances. The mine-haulage system may be extended or surface trams built to the mill or shipping point if a practical track grade is possible and if the distance is relatively short. Aerial trams have a special field of usefulness for transportation over steep or excessively rough terrain.

Trucks generally are used in preference to teams, except on very poor or unusually steep roads or in mountainous regions of heavy snowfall. Ore usually is packed on animals only as the last resort.

The most common method of transporting ore from the mine to the mill in western gold mining is by trucks for distances of 1 mile or more. Trucks also are used for shorter distances; in one case it was found more economical to use a truck where the haul was only $\frac{1}{4}$ mile than to tram the ore by hand. Packing is used only for transporting relatively small tonnages where there are no passable roads. If any considerable amount of ore is to be mined, a road or an aerial tramway usually is built.

PART I—TRUCKING

The cost of trucking is governed by the condition of the roads, length of haul, regularity of shipments, and the capacity and fitness of the trucks used. On long hauls, relatively less time is taken to load and unload the trucks, hence, lower ton-mile costs are obtained. Moreover, distance has a further bearing on costs in that the cost of trucking would be less at a mine where the last of a number of round trips would be just completed at the end of a shift than at a property where the length of haul was such that the time of making a trip could not be divided evenly into the number of hours in a shift. Costs are substantially lower when equipment can be employed steadily than when the hauling is intermittent.

Two popular makes of trucks, each with a rated capacity of $1\frac{1}{2}$-tons, are used in more instances for hauling gold ore or concentrate in the western mining districts than trucks of any other one size. These $1\frac{1}{2}$-ton trucks commonly haul 4-ton loads and occasionally are loaded up to 6 tons. For hauling overloads, the trucks are equipped

[1] "Reprinted from U. S. Bureau of Mines Information Circular 6898."
[2] Supervising engineer, Metal Mining Methods Section, Mining Division, U. S. Bureau of Mines.

with "helper springs" and oversize dual tires. Three and one-half ton trucks, on which loads up to 7 tons are hauled, are the next most numerous for this service. Trucks with a rated capacity up to 12 tons are used, but in relatively fewer numbers. Some of the long-distance trucking is done by commercial highway trucking companies, which generally use large trucks.

The life of a small truck, when regularly and heavily overloaded, is shorter than that of a larger one with a rated capacity more nearly equal to that of the loads actually hauled. Moreover, the upkeep of the smaller trucks is higher. The purchase of the cheaper small trucks is justified, however, where there may be doubt as to the duration of a hauling job. Lighter trucks are used more commonly for relatively short trips and heavier ones for long-distance hauling. Some contractors prefer light trucks for crooked roads, as better time can be made with them.

Trucks with four-wheel drive are used on roads with steep grades. One make of truck is reported to be able to go up a maximum grade of 40 per cent when empty. In the summer of 1934, a truck with four-wheel drive was used in hauling concentrate from the Mattie mill at Idaho Springs, Colo. The first half mile below the mill had an average grade of 25 per cent. Ordinary passenger cars could not negotiate the hill.

Ore usually can be transported long distances in carload lots cheaper by rail than by trucks. The railroad rate increases with the grade of the ore; with very high-grade material, trucking may be less costly than shipping by rail. The freight rate on less than carload lots usually is more than for trucking. Moreover, shipping ore or concentrate by truck has an advantage in that any size lot may be marketed. With equal rates, shipping carload lots by rail usually is preferred to contract trucking. The routine for paying for lost shipments and the railroad's financial ability to pay losses has been well-established; many small trucking contractors would have difficulty in paying for a lost lot of high-grade ore or concentrate.

Teams seem to be preferred for hauling ore over rough roads with steep grades for relatively short distances and in regions of heavy snowfall. The cost of teaming, however, for longer distances over steep, rough roads may be about the same as for trucking. For instance, ore was hauled by teams from the Paymaster mine to Townsend, Mont., in the summer of 1933, a distance of 30 miles, for $3.50 per ton. The roads were passable for trucks for part of the year, but the cost of the upkeep of the trucks made this form of hauling more expensive. Usually, however, if very much hauling is to be done the roads are improved and trucks used.

The difficulty of trucking increases as snow begins to fall. On well-traveled highways the roads are kept open, and trucks can be used throughout the year. On less-traveled roads, in regions of heavy snowfall, trucks can not be used in the winter. Teams and pack animals are used for hauling 10 tons of concentrate daily from the Camp Bird mine to Ouray, Colo. The concentrate is packed on mules 3 miles and is then hauled 6 miles in two wagons with four-horse teams. One round trip is made daily with the wagons. The contract price is $6 per ton from the mine and $9 for the back haul. The $6 includes

loading the concentrate in railroad cars when a shipment has been accumulated. Doubtless the ore could be trucked more cheaply over the lower six miles during the summer, but as horses and wagons were required for winter work they were used the year around by the contractor.

Trucking of supplies from Grangeville, Idaho, to the Gnome mine at Oro Grande, Idaho, a distance of 59 miles, cost $10 per ton in the summer and $15 in the winter. A part of the way was improved, and the rest was ordinary mountain road. When the roads were bad the load was transferred from an ordinary truck at the halfway point to a truck with dual wheels and a four-wheel drive. The final 5 miles were made by sleigh.

A total of 3,600 tons of freight was taken 54 miles from the railhead over snow to the Sherritt-Gordon[3] mine in 1930; 19 miles was over portages and 36 miles over frozen lakes. The portages were not graded. Tractors with a train of sleighs were used; the cost was $0.27 per ton mile. During the previous winter, 2,600 tons were taken 80 miles at a cost of $0.56 per ton-mile. At the peak, 150 teams and 4 tractors were in use.

During the winter of 1934-35, supplies were hauled to the Bussieres mine in Quebec, a distance of 26 miles, on snow over frozen muskeg in sleds pulled by a tractor at a cost of $6 per ton or $0.23 ton mile, according to Chas. F. Jackson, chief engineer, Mining Division, Bureau of Mines. The time of making a trip one way ranged from 5 to 48 hours.

Trucking of ore and concentrate at most small mines in the west is done on contract. Contractors usually can quote rates lower than the cost of doing the work on company account. This is especially true if the same trucks can be used concurrently on several jobs. Moreover, the mining companies are saved the purchase price of the necessary equipment.

A single contractor hauled 260 tons daily (the mill capacity) to the Katharine mill in Mohave County, Ariz., from four or five different mines. The distance ranged from 4 to 12 miles and the cost per ton mile from 5 to 9 cents. He used five 3½-ton trucks, loaded with 7 tons each, and two 1½-ton trucks, on which 3 to 4 tons were hauled. One driver for each truck and a mechanic were employed. The trucks were run one shift, ranging from 10 to 14 hours daily; occasionally one or more trucks would be run an extra shift, in which case the contractor would drive one truck and, if needed, an extra driver would be hired. The cost per mile would be appreciably higher should the hauling from each mine be done independently.

COSTS OF TRUCKING

The costs of trucking in western gold-mining districts are given in tables 1, 2, 3, 4, 5, and 6. The prices shown are contract prices unless otherwise specified. Table 1 contains the rates for moving about 450 tons daily to three milling plants in the Oatman and Katharine districts in northern Arizona and occasional carload lots from neighboring districts to the railroad.

[3] Canadian Institute of Mining and Metallurgical Engineers, History, Development, and Production Plans at Sherritt-Gordon Mines: Trans. vol. 33, 1930, pp. 245-271.

TABLE 1. TRUCKING COSTS IN ARIZONA

FROM—	TO—	Distance, miles	Tons, daily	Year	Condition of road	Shoveling	Size loads, tons	Price per ton[1]	Cost per ton-mile	Remarks
Oatman District:										
Big Jim mine	Telluride mill	1	45	1933	Good	None	7	$0 30	$0 30	
Ruth-Rattan mine	Tom Reed mill	9	40	1935	Fair	None	7	1 25	14	
Mossback mine	Tom Reed mill	9		1934	Fair	None	7	1 25	14	
German-American mine	Tom Reed mill	4 to 5	15	1935	Fair	None	7	50	10	
German-American mine	Tom Reed mill	4 to 5	15	1935	Fair	In	7	75	15	
Midnight mine	Tom Reed mill	7	2	1935	Good	In	7	1 25	18	
United Western mine	Tom Reed mill	2	20	1935	Excellent	None	7	35	18	
Katherine District:										
Tyro mine	Katherine mill	6	60		Fair	None	7	50	08	3½-ton trucks loaded to 7 tons
Roadside mine	Katherine mill	4	(2)	1935	Good	None	7	30	08	3½-ton trucks loaded to 7 tons
Arabian mine	Katherine mill	8	(2)	1935	Good	None	7	40	05	3½-ton trucks loaded to 7 tons
Portland mine	Katherine mill	15	(2)	1935	Fair	None	7	1 12	07	3½-ton trucks loaded to 7 tons
Frisco mine	Katherine mill	10	(2)	1935	Good	None	7	60	06	3½-ton trucks loaded to 7 tons
River Range:										
Klondyke mine	Tom Reed mill	82	15	1935	Fair	In	7	5 00	06	
Eldorado mine	Tom Reed mill	75		1935	Good	In	7	6 00	08	Odd lots
Pope mine	Kingman R.R. station	53		1935	Good	In	7	3 50	07	50-ton lots
Pilgrim mine	Midvale, Utah	515		1935	Excellent			[3]15 00	03	Odd lots, concentrate, sacks

[1] All hauling done by contract unless otherwise specified.
[2] Some contractor did all hauling to Katherine mill (total 250 tons daily).
[3] This includes $2 per ton highway tax in Utah. New rate after new road built across dam, which eliminates curves and hills, $11, exclusive road tax.

TABLE 2. TRUCKING COSTS IN ARIZONA

FROM—	TO—	Distance, miles	Tons, daily	Year	Condition of road	Shoveling	Size loads, tons	Price per ton	Cost per ton-mile	Remarks
Keystone, Kingman	Los Angeles	350	3	1935	Excellent			$5 00	$0 014	Back-haul in highway trucks
Keystone, Kingman	San Francisco	700	3	1935	Excellent			8 50	012	Back-haul in highway trucks
Lelan-Divide Mayer	Clarkdale	51		1936	Good	In		4 50	09	33-ton lot
Swastika mine	Mayer	23		1936	Fair	In and out		4 00	17	Concentrate, car lots
Richinbar mine	Mayer	19		1936	Fair	In and out		3 50	18	Concentrate, car lots
Golden Turkey mine	Mayer	15	5	1936	Good	In and out		2 00	13	Company account
Golden Belt, Mayer	El Paso, Tex.	510	3⅓	1936	Highway	Sacked		[1]8 15	016	Concentrate
Oro Flame mine	Prescott	10		1934	Good[2]	Sacked	5	[3]60	06	Concentrate, car lots
Davis-Dunkirk mine	Prescott	16		1935	Fair	Sacked	3 and 6	[4]3 00	19	Concentrate, car lots
Tillie Starbuck	Davis-Dunkirk mill	1½	25	1934	Fair	In	6	1 00	67	Shovel from dump, some sorting
Verde Central mine	Jerome	2	55	1931	Good	None	10	[5]25	12	Company account
Golden Slipper mine	Hot Springs Junction	13		1934	Fair	In and out		1 37	11	Car load lots
Humbug mine	Morristown	50		1934	Rough	Sacked	7	5 00	10	Concentrate, 7-ton lots
Morristown	El Paso, Tex.	500		1934	Highway	Sacked	7	12 00	024	Concentrate, 7-ton lots
Gold King	Tucson	70		1933	Fair	In and out	7	7 50	11	100-ton lots
Montana	Sahuarita	40	24	1931	Fair	In and out	[6]12	4 50	11	Company account
Mammouth mine	Mohawk mill	3	50	1933	Fair	In		25	08	
Dos Cabesos	Wilcox	14		1935	Fair	In and out		2 50	18	Intermittent 40-ton lots

[1] Taken by highway trucking firm as backhaul to Phoenix, then used to round out loads of bulky material to El Paso.
[2] 1 mile very rough and steep, three trips daily.
[3] On company account; does not include depreciation or major repairs.
[4] First 1½ miles rough, up 1,500 feet vertical; 3 tons only hauled to divide.
[5] Does not include depreciation.
[6] With trailer, round trip 16 hours.

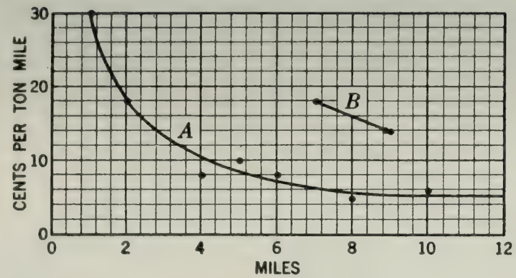

Figure 1.—Curve A. Ore-trucking costs, Oatman and Katherine Districts, Arizona. Sustained tonnages are hauled over good dirt roads with no shoveling. Curve B. Same as A, except that the roads are poorer or the ore is shoveled into the trucks.

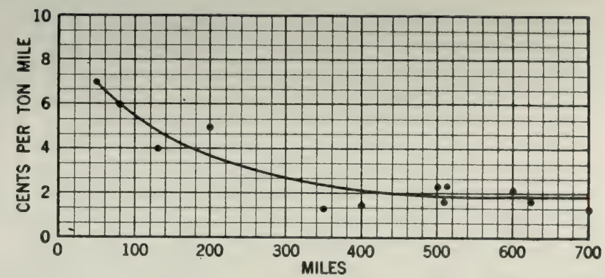

Figure 2.—Costs of trucking ore and concentrate long distances in irregular small lots in California and Arizona.

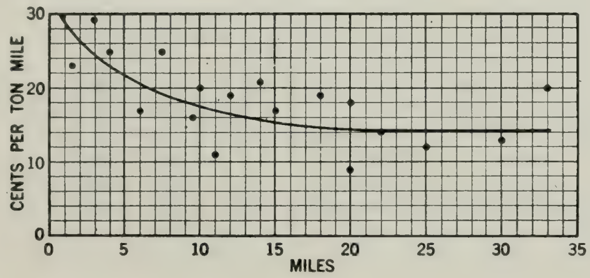

Figure 3.—Ore-trucking costs, Nevada; mostly fair dirt roads and irregular lots.

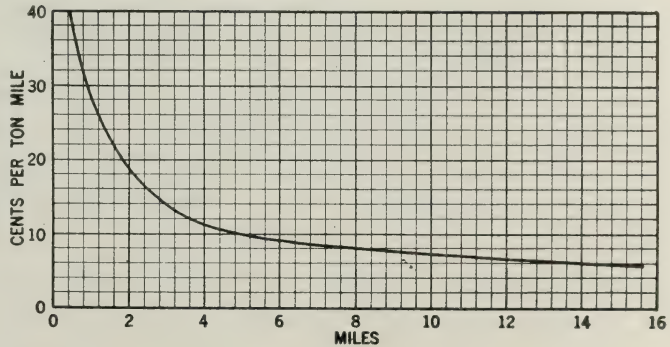

Figure 4.—Rates of trucking regular tonnages of ore over good dirt roads where trucks can be employed steadily and with no shoveling in or out under conditions existing in northwestern Arizona and California.

TABLE 3. TRUCKING COSTS IN CALIFORNIA

FROM—	TO—	Distance, miles	Tons, daily	Year	Condition of road	Shoveling	Size loads, tons	Price per ton	Cost per ton-mile	Remarks
Banner mine, Nevada City	Lava Cap mill	2	75	1935	Fair	None	5	$0 35	$0 175	
Hoge mill, Nevada City	Selby smelter	130	2	1935	Excellent	In and out		5 00	04	6-ton lots
Easy Bird mine, Mokelumne Hill	Easy Bird mill	¼	80	1935	Good	None	3½	10	40	1½-ton truck
Easy Bird mill	Jackson	13	3	1935	Good	In and out		2 00	15	Concentrate; 6-ton lots
Alpine mine, Georgetown	Beebe mill	3	60	1935	Good	None		44	15	
Montezuma mill	Eldorado	8	6	1935	Excellent	In and out		1 10	14	Concentrate; carload lots
Middle Butte mine, Mojave	Tropico mill	9	25	1936	Good	None		1 00	11	
Rogers and Gentry, Neenach	Tropico mill	34	8	1935	Good	None		1 70	05	
Golden Bee mine, 29 Palms	Tropico mill	200	2	1935	Fair	In		10 00	05	15-ton lots
Branch mine, Victorville	Tropico mill	75		1935	Good	In	5	3 50	05	5-ton lots
Silver Queen mine	Mojave	2	40	1935	Poor	Out		1 00	50	
King Solomon mine, Randsburg	King Solomon mill	2	17	1935	Fair	None		17	085	Company account; no depreciation
Big Blue mine, Kernsville	Big Blue mill	¾	115	1935	Fair	None	12	20	26	
Big Blue mill	Selby	400		1935	Excellent	In and out		6 00	015	Concentrate
Cardinal mill, Bishop	Laws, Nevada	20	4	1934	Fair	In and out		2 50	125	Concentrate; carload lots
Old Pete mine	Ludlow	4	40	1934	Fair	None		1 00	25	
Gold Coin Apex mine, Needles	Selby	625		1935	Excellent	Out	6	10 00	016	12-ton lots

The costs per ton-mile as ordinates and length of haul in miles as abscissas are plotted on figure 1. Curve *A* shows the relation of cost per mile ton to length of haul when a definite daily tonnage is handled over good dirt roads; the trucks are loaded from chutes, dumped into bins, and are steadily employed. Curve *B* shows the higher costs at three mines where the roads are in poorer condition or where the ore is shoveled into the trucks. Table 2 contains further costs in Arizona districts. California costs are given in table 3.

Figure 2 shows the relation of costs per ton-mile plotted against length of haul for long-distance hauling on highways in Arizona and California. The data are taken from tables 2 and 3. Considerable merchandise is moved out of Los Angeles, San Francisco, and El Paso by highway trucking companies. The low rates shown in the tables and on the curve for distances of 300 miles or more are made possible by the desire of these trucking companies to obtain freight for a return haul in trucks that otherwise would be unloaded.

In the summer of 1935 California trucking companies, in order to use idle equipment, were willing to take contracts to transport 50 tons or over daily for distances of 199 miles or more for $0.03 per ton-mile; no return-haul freight was to be expected. These low rates probably could not be expected if the trucks could be used full time for hauling general merchandise.

The company that operated the Tropico custom mill (table 3) trucked ore from outlying mines to its mill at a flat rate of $0.05 per ton-mile for distances of over 20 miles.

The dirt roads in the Arizona and California districts covered in this paper seldom are muddy; moreover, there is almost a complete absence of snow. Trucking costs would be higher than those included in the tables if it were necessary to contend with mud or snow. In most of the long-distance hauls shown in the tables, the trucking rates are equal to or less than railroad freight tariff. For example, the cost of transporting concentrate in sacks from the Golden Belt mine near Mayer, Ariz., to El Paso, Tex. (table 2), a distance of approximately 500 miles, is $8.15 per ton. The smelting company makes an extra charge of $0.50 for handling sacked concentrate. An adjoining mine ships approximately the same grade of concentrate without sacking in carload lots to El Paso by freight at a cost of $7.85 per ton from Mayer; the trucking cost from the mine to Mayer is $2.00 per ton. In this case the cost by trucks is less, but with the lower grade concentrate a saving would be made in shipping by freight.

Trucking costs in Nevada are shown in table 4. The costs per ton-mile are plotted against length of haul in figure 3. The curve shows a general decline in costs per ton-mile as the distance is increased. Data as to road conditions, regularity of shipments, and whether the loads were shoveled in or out are largely lacking.

Trucking costs in Colorado, Utah, and New Mexico are given in table 5, and for Montana, Idaho, and Oregon in table 6.

TABLE 4. TRUCKING COSTS IN NEVADA

FROM—	TO—	Distance, miles	Tons, daily	Year	Condition of road	Shoveling	Size loads, tons	Price per ton	Cost per ton-mile
Divide	Tonopah	6		1935	Good			$1 00	$0 17
Peters mine	Mina	12	2	1935				2 25	19
Ashby mine	Mina	20	2	1935				1 75	09
Brown Palace mine	Sulphur	8		1935				2 00	25
Brown Palace mine	Seven Troughs	30		1935				4 00	13
Eureka-Croesus mine	Eureka	4	4	1935				1 00	25
Gold Bar mine	Beatty	11		1935				1 25	11
McCrea mine[2]	End Truck road	½	2	1935	Uphill	In and out	¾	1 75	3 50
End Truck Road mine	Carrara	20		1935				3 50	18
Capicorn mine	Beatty	22		1935				3 00	14
Gibraltar mine, Carrara	Gibraltar mill	2½	40	1934			5	40	16
Copper Basin mine	Battle Mountain	9½		1935				1 50	16
Plumas mine	Battle Mountain	15		1935				2 50	17
Tomboy mine	Battle Mountain	14		1935				3 00	21
Copper Mountain mine	Battle Mountain	18		1935				3 50	19
Last Chance mine	Battle Mountain	10		1935				2 00	20
Gold Dome mine	Battle Mountain	33		1935				6 50	20
Little Gem mine[3]	Beowawe	25		1935				3 00	12
Blossom mine	Searchlight	3	10	1935	Fair	In and out	3	1 00	33
Ely Gold mine	Ely	1½	50	1935	Fair	None	5	35	23

[1] Data supplied by W. O. Vanderburg, associate mining engineer, Reno, Nev., except last two items.
[2] In 3-wheel motorcycle with box.
[3] Contract, recent company, cost $1.10 per ton.

TABLE 5. TRUCKING COSTS IN COLORADO, UTAH, AND NEW MEXICO

FROM—	TO—	Distance, miles	Tons, daily	Year	Condition of road	Shoveling	Size loads, tons	Price per ton	Cost per ton-mile	Remarks
Colorado:										
Perrin mine	Blackhawk	3	10	1934	Fair	None		$0 70	$0 23	
Mattie mill	Idaho Springs	3½	5	1934	(1)	In	6½	1 50	43	4-wheel drive trucks, carload lots
Grand Republic mine	St. Joe mill, Boulder	7	50	1934	Fair[2]	In[3]	3⅓	1 50	21	3 new $1,000 1½-ton trucks
Cold Springs mine	St. Joe mill, Boulder	7	25	1935	Fair[2]	In[3]	3⅓	1 50	21	3 new $1,000 1½-ton trucks
Slide mill	Boulder	18	4½	1934	Good	In and out		1 75	10	Concentrate; carload lots
Orpha May mine	Cripple Creek	½	40	1935	Fair	½ in		40	80	
Lease, Stratton mine	Cripple Creek	1	40	1935	Fair	In		50	50	
Veneer mine	Leadville	½	25	1935	Fair	In and out	5	1 00	2 00	
South London mine	Leadville	87	15	1934	Good	In and out		4 07	05	Concentrate
Gold King mine	Hesperous	22		1934	Good	Out		2 00	09	Company account
Utah:										
Clementine mine	Midvale	8		1934	Excellent	In and out		1 50	19	8-ton lot
Yankee mine	American Fork	13	50	1934	Fair	None		1 12	09	
Palmer mine	Gold Hill	1½	12	1934	Fair	Out	12	75	50	$0.50 per ton extra for loading into box cars
Cane Springs	Gold Hill	½		1934	Fair	In and out	12	50	1 00	Odd carload lots
Buckskin Mountains	Cedar City	130		1934	Good	In and out		12 00	09	Odd lots
Copperhead mine	Delta	30		1934	Poor	Out	4	2 25	075	One 100-ton lot; contractor lost money
New Mexico:										
Crow-Strom mine	Silver City	11		1933	Fair	In and out		1 00	09	40-ton lots
Cactus mine	Vanadium	70		1933	Good	In and out	10	2 50	036	40-ton lots
Bonanza mine, Hillsboro	El Paso, Tex.	125		1933	Good	In and out		5 00	04	Concentrate

[1] One-half mile rough road, 25 per cent grade; rest road good.
[2] All running in low or second gear; up 1,000 and down 1,500 feet.
[3] Mining company furnishes one man to assist truck driver to load.

TABLE 6. TRUCKING COSTS IN MONTANA, IDAHO, AND OREGON

FROM—	TO—	Distance, miles	Tons, daily	Year	Condition of road	Shoveling	Size loads, tons	Price per ton	Cost per ton-mile	Remarks
Montana:										
Gold Coin mine	Gold Coin mill, Silver Lake	½	14	1933	Fair	In		$0 50	$1 00	Open-cut; driver helps load
Gold Coin mine	Gold Coin mill, Silver Lake	½	7	1933	Fair	None		35	70	Loaded from chute
Rock Creek	Anaconda	125		1933	(1)	In		8 00	06	Odd lots
Southern Cross	Anaconda	20	10	1933	Excellent	None		1 50	08	
Jewell Lease	Butte	1		1933	Good	In and out		1 00	1 00	10-ton lots
Garnet	Bearmouth	11		1933	Fair	In and out		2 00	18	Occasional carload lots
Garnet	Bearmouth	13		1933	Fair	(2)		3 00	23	Occasional carload lots
Jardine mill	Gardiner	6	6	1933	Good	Out		1 50	25	Carload lots
Idaho:										
Atlanta mill	Mountain Home	85	10	1934	Fair; steep			14 00	16	Sacked concentrate, 5 months per year
Champlain mine, Haily	Champlain mill	7	25	1934	Fair	In		1 00	14	
Oregon:										
Quartzburg mine	Baker	80		1933	Good	In	5	6 00	08	Carload lots

[1] 106 miles highway, 12 miles fair, 7 miles very poor.
[2] Hauled 1 mile over ridge then transferred to another truck.

The individual items making up the costs shown in the tables are largely lacking; most of the figures were supplied by the mining companies to which this information was not available. The classified costs in one instance for trucking from the lower terminal of the aerial tramway of the Yankee mine (table 5) to the railroad, a distance of 12 miles, follow:

	1932	*January 1933*
Labor	$0.27	$0.21
Supplies	----	.59
Miscellaneous	.85	.32
Total	$1.12	$1.12

The items for ''miscellaneous'' contain service expenditures for road repairs.

Summary of Costs

The costs of trucking vary widely in different sections of the country, as shown in the tables. The costs depend mainly upon the condition of the roads, length of haul, daily tonnage handled, and regularity of the shipments. The roads to many small mines are unimproved; this condition is directly reflected in the relatively higher costs in many instances shown. As production increased, more work usually is done on the roads, which, together with more regular shipments results in lower costs.

The costs of trucking regular tonnages of ore over good dirt roads where the trucks can be steadily employed and with no shoveling in or out under conditions existing in gold-mining districts in northwestern Arizona and California in 1935 may be summarized as follows:

Distance, miles	*Cost per ton-mile*
Up to 1	Average $0.35
1 to 2	Average .22
2 to 5	Average .12
5 to 10	Average .09
10 to 20	Average .06
20 to 100	Average .05

The curve in figure 4 shows the same generalized costs. The rates for hauling over poor roads or of irregular or small lots would, of course, be much higher. About $0.35 per ton divided by the miles hauled should be added to the above figures for each time the ore is shoveled.

PART II—PACKING

Ore is transported on the backs of animals when relatively small tonnages of high-grade material are hauled down steep mountain sides or over rough country where no roads exist. When any considerable tonnage is to be handled, roads usually are built and either wagons or trucks are used.

Burros are used largely for packing ore in the Southwest and mules elsewhere in the West. Burros can find their own food and may be obtained cheaply in the desert mining regions. Ownerless animals are a nuisance in some Arizona mining districts. Mature burros weigh

400 to 600 pounds and may be purchased at from $2.50 to $10 each, or ownerless animals may be rounded up on the desert.

Mules carry heavier loads and usually cover greater distances per day than burros. When used steadily, mules are fed, the cost of feeding them being higher than that of feeding a burro. A burro withstands the summer heat in the desert better than a mule. Pack mules weighing about 800 pounds cost from $35 to $50; those weighing 900 to 1,000 pounds cost from $100 to $125. Heavier mules are used seldom as pack animals.

The size of the load that an animal can carry and the distance that can be covered per trip depend upon the steepness and roughness of the trails. Burros commonly carry as much as 285 pounds down steep but fair trails for distances up to 2½ miles. The maximum load for a 5-mile trip is 250 pounds; the usual load, however, is 200 pounds. For all-day trips the usual load is about 150 pounds per burro. Daily round trips usually are 5 to 8 miles each way; one-way trips with the animals loaded are from 10 to 14 miles long. Mexican contractors frequently supply isolated camps with wood. A cord of dry pine (600 to 800 pounds) usually is packed on four burros for several miles.

Because of the work involved in loading and unloading, packers usually do not unload the animals until the end of a trip. When this procedure is followed, considerably longer distances can be traveled in a day. A prospector in the Galuiro Mountains of Arizona periodically covers 25 miles to Klondyke in a day with a string of 10 large burros, each loaded with 150 pounds of ore. He unloads, waters, and rests the animals at noon. He rides a burro also. The animals could not make the trip regularly; the above performance is unusual. Usually 20 miles would be considered a good day's journey under similar conditions.

Strong mules can carry up to 420 pounds each for 3 or 4 miles. Usually, however, the load per mile is not over 300 pounds, except for very short distances. Average mules are loaded with 200 to 250 pounds for trips of 5 or 6 miles, with lighter loads for longer distances. Usually they carry about 175 pounds on all-day trips. Round trips loaded one way usually are 10 to 14 miles each way; one-way trips, loaded, are 14 to 20 miles. By unloading and resting the animals enroute, 200 pounds may be carried 20 or 25 miles each day.

Mules seldom are loaded with more than 200 pounds each when used for packing supplies, and longer distances are traveled in a day than when ore is being packed.

Horses are used largely in the Northwest for packing supplies to small properties away from roads. Usually they are loaded with 150 to 200 pounds and are good for about the same distance as a mule. Horses must be better fed than mules and cost more to keep. Moreover, they can not stand the work as well as mules.

The loads that can be carried and the distances that can be traveled per day will, of course, depend upon the size and physical condition of the animals used. The burros used in the Southwest average about 500 pounds in weight, but there is considerable difference in the size of pack mules used throughout the country. The size of loads carried has a bearing on the ease with which pack animals can be handled. A fractious animal usually becomes docile when loaded heavily.

Although burros with relatively light loads can be turned loose and driven by a man on foot, only heavily loaded mules can be handled in this manner. Unless trained for the work, each mule or horse in a pack is tied to the one ahead, the leader generally being led by a mounted man.

The hand labor of saddling, loading, and unloading the animals is responsible for a large part of the cost of packing. Usually one man can handle a string of 5 to 7 pack animals and two men can handle 10 to 15.

At the Humbug mine about 70 miles from Wickenburg, Ariz., burros were used to bring ore to the mill from vein outcrops over steep rough country with no trails. Usually 1 ton was loaded on 7 animals, but in very rough country 8 to 10 animals would be used. Five round trips, averaging 1 mile each way, were made daily. Two men with saddle horses handled a string of 10 burros. The work was done on company account, and the animals were fed. Three bales of hay and a small amount of grain were fed daily. The cost of feed was about \$0.35 daily per burro. Feed, shoeing, and repairing of gear cost about \$0.50 daily per animal.

Near Prescott, Ariz., in 1934, a man afoot with eight burros made three round trips of $1\frac{1}{4}$ mile daily. A ton was hauled to the load. He earned \$6 daily. The animals were turned loose at night to graze.

At the Camp Bird mine in Colorado, two men with saddle horses manage a string of 28 to 30 selected mules, which is about twice the usual number. The packing work is systematized, efficient gear is used, and loading and unloading platforms minimize the physical labor of handling the material. Moreover, the lead saddle horse, to which the first mule in the string is tied, has been trained to start and stop the pack animals at command at the terminals, which leaves both men free to attend to the loading and unloading. Two round trips of 3 miles daily are made over a good trail. The loading point is at an elevation of about 12,000 feet, and the point of delivery is 1,500 feet lower down. Ten tons of concentrate in bags holding about 70 pounds each are handled daily. Each mule is loaded with six bags (400 to 420 pounds), except a few small animals, which are loaded with five sacks. Two men tend the stock and do all the shoeing. In addition, mill and mine supplies are carried on some of the return trips. The maximum load uphill is 200 pounds per animal.

In packing crude ore two boxes, one on each side, generally are fitted to the pack saddle on each animal. The boxes can be dumped without being removed from the animal. They may be loaded while on the animal or filled on the ground and then raised into place. In the latter case, two men are required to load. In some localities, however, where enough packing has to be done to justify the expenditure, the animals may be led under a chute for loading the boxes.

Concentrate generally and ore occasionally is sacked for animal transportation. This practice is always followed when the material is to be handled more than once in transit.

The same type of pack saddle is used in most districts, but the gear used with the saddles varies greatly in different sections of the country. The proficiency of packers also varies greatly. An expert packer with

proper equipment can load a string of animals in half the time that is taken by a less-experienced man.

Although on ordinary roads ore can be hauled more cheaply in wagons than by packing, the latter method seems to have an advantage for relatively small tonnages on very steep roads, particularly in regions of heavy snowfall. Loads can be brought down much steeper grades with pack animals than in wheeled vehicles; moreover, where the snowfall is heavy and the winter long, packing over the whole year may be cheaper than the combined cost of hauling and keeping the roads clear of snow. This is true at the Camp Bird mine. Trucks with four-wheel drives can be taken to this mine from the camp site during about four months, and ordinary trucks can be taken from the railroad to the camp site during six months of the year. Pack animals going over a trail each day keep the snow packed. Likewise, but to a less extent, roads can be kept open with teams; snow plows are needed to keep roads open for trucks or automobiles at high elevations in most of the mountainous regions of the West.

When the surface is smooth, ore can be dragged down a mountain side with fewer animals than would be required to pack it. At the Wedge mine, near Marysvale, Utah, ore was dragged 2½ miles down a steep mountain side in the summer of 1933 at a contract price of $2.50 per ton. The drag consisted of the front part of the running gear of a wagon with two trailing poles; it was pulled by two horses. The team and load were handled by two men. Two trips were made daily with two tons to the load. The ore was then loaded into a truck and taken to the railroad, seven miles distant, for $2.50 per ton. Up freight from the railroad to the mine cost $15 per ton.

Toboggans pulled by horses, rather than packing, are used in deep snow in some localities. In the spring of 1933 freight was being taken from Mountain Home to Atlanta, Idaho, 54 miles by truck, 10 miles by sleigh, 8 miles by toboggan over the summit covered with deep snow, and the final 8 miles by sleigh. Two men with two horses took two toboggan loads of 1,400 pounds each over the mountain. The contract price for the whole distance was $60 per ton.

At the Gold Bug mine, in 1934, on a branch of Rock Creek near Clinton, Mont., ore was dragged down a trail in a stone boat with one horse for a distance of 3,750 feet. The drop in elevation was about 1,000 feet. A load of 1,500 pounds was hauled in summer and one ton in winter. The boat was braked by a contrivance that dug into the ground. Three round trips were made per day. With labor at $4, and $1 per day for the horses, the cost in the summer was $2.22 per ton and $1.67 per ton in winter. Although packing probably would have been cheaper, no pack animals were available; only about 20 tons were taken down monthly.

Costs of Packing

Packing usually is done cheaper by contract than on company account. This form of transportation generally costs less in the Southwest, where burros are plentiful, than elsewhere in the West. Many of the native Mexican farmers or small ranchers in the Southwest have a number of these animals and frequently are glad to take contracts for packing ore in the vicinity of their homes. The contractor

TABLE 7. COSTS OF PACKING ORE

Place	Distance one way, miles	Trips daily	Tons, daily	Kind of animals	Number of animals per ton	Condition of trail	Drop in elevation, feet	Year	Cost per ton	Cost per ton-mile	Remarks
Dos Cabesos, Ariz.	2	3	......	Burros	7	Fair	1,000	1934	$1 50	$0 75	Contract
Dos Cabesos, Ariz.	1	5	5	Burros	7	Fair	700	1935	1 00	1 00	Contract
Ruby, Ariz.	5	1	......	Burros	8	Fair	...	1935	3 50	70	Contract
Wickenburg, Ariz.	1	5	4	Burros	7	Poor	1,000	1935	3 00	3 00	Company account; 10 burros, 2 men on horses
Superior, Ariz.	½ to 1½	......	25	Burros	......	Fair	800	1934	1.00 to 1.50	1.00 to 2.00	Contract
Prescott, Ariz.	¾	5	......	Burros	......	Steep	......	1934	1 25	1 66	Contract
Prescott, Ariz.	1¼	3	3	Burros	8	Steep	1,000	1934	2 00	1 60	Contract
Camp Bird, Colo.	3	2	[1]10	Mules	5 to 6	Good	1,500	1934	([2])	......	28 to 30 mules, 2 horses, and 2 men. Contract
Questa, New Mexico	¼	......	......	Burros	......	Fair	300	1930	1.00 to 1.50	4.00 to 6.00	Contract

[1] Concentrate.
[2] Cost $6 per ton included with six mile wagon haul; up freight, $8 per ton.

usually walks and thus saves the expense of feeding a saddle horse, which he would demand if working on company account; moreover, he seldom buys feed for his animals for relatively short trips. He usually has a few extra animals to replace those showing the effect of hard work.

Costs of packing, the size of loads carried, the distance covered at nine mines are shown in table 7.

Summary of Costs

Packing costs generally are considered to be about $1 per ton-mile for moderate distances. Although lower contract prices are in effect in the Southwest, $1 per ton-mile appears low for most localities. For example, a man with 7 burros carrying a ton to the trip can make five 1-mile trips per day; at $1 per ton, his total gross earning is $5 per day. Should he be paid the usual mine surface scale ($4 per day) and the burros be fed and shod ($0.50 per day per animal), the cost would be $1.50 per ton-mile without considering the cost of replacement of the animals.

For short trips (½ mile or less) the cost per ton-mile is high, as most of the time is consumed in loading and unloading the animals. For longer trips less time is taken for loading but the loads are lighter.

A fair contract price for packing with burros over fair trails may be summarized as follows:

½ mile	$2.00
1 mile	1.50
2 miles	1.00

The cost of packing with mules will average 25 to 50 per cent higher.

STRATEGIC MINERALS ACT

This act to provide for the common defense by acquiring stocks of strategic and critical materials essential to the needs of industry for the manufacture of supplies for the armed forces and the civilian population in time of a national emergency, and to encourage, as far as possible, the further development of strategic and critical materials within the United States for common defense, was passed by Congress and approved by the President June 7, 1939.

The text of the act follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress Assembled, That the natural resources of the United States in certain strategic and critical materials being deficient or insufficiently developed to supply the industrial, military, and naval needs of the country for common defense, it is the policy of Congress and the purpose and intent of this Act to provide for the acquisition of stocks of these materials and to encourage the development of mines and deposits of these materials within the United States, and thereby decrease and prevent wherever possible a dangerous and costly dependence of the United States upon foreign nations for supplies of these materials in times of national emergency.

SEC. 2. To effectuate the policy set forth in section 1 hereof the Secretary of War, the Secretary of the Navy, and the Secretary of the Interior, acting jointly through the agency of the Army and Navy Munitions Board, are hereby authorized and directed to determine which materials are strategic and critical under the provisions of this Act and to determine the quality and quantities of such materials which shall be purchased within the amount of the appropriations authorized by this Act. In determining the materials which are strategic and critical and the quality and quantities of same to be purchased the Secretaries of State, Treasury, and Commerce shall each designate representatives to cooperate with the Secretary of War, the Secretary of the Navy, and the Secretary of the Interior in carrying out the provisions of this Act.

SEC. 3. The Secretary of War and the Secretary of the Navy, when they deem such action appropriate because the domestic production or supply of any of the above materials is insufficient to meet the industrial, military, and naval needs of the country, shall direct the Secretary of the Treasury, through the medium of the Procurement Division of his Department and from the funds authorized by the provisions of this Act, to make purchases of such materials in accordance with specifications prepared by the Procurement Division of the Treasury Department and approved by the Secretary of War and the Secretary of the Navy, and to provide for the storage and maintenance, and, where necessary to prevent deterioration, for the rotation of such materials. To accomplish such rotation, the Secretary of the Treasury, with the approval of the Secretary of War and

the Secretary of the Navy, is authorized to replace acquired stocks of any such material subject to deterioration by equivalent quantities of the same material in such manner as he deems will best serve the purposes of this Act. The Secretary of the Treasury is empowered to meet, out of the funds authorized in this Act, expenses necessary to accomplish such rotation. The Secretary shall include in his annual report to Congress a detailed statement of expenditures made under this section and the method of rotation employed. The materials so purchased shall be stored by the Procurement Division of the Treasury Department on military and naval reservations or in other locations approved by the Secretary of War and the Secretary of the Navy.

Sec. 4. Materials acquired under this Act except for rotation to prevent deterioration shall be used only upon the order of the President in time of war, or when he shall find that a national emergency exists with respect to national defense as a consequence of the threat of war.

Sec. 5. Purchases under this Act shall be made in accordance with Title III of the Act of March 3, 1933 (47 Stat. 1520), but a reasonable time (not to exceed one year) shall be allowed for production and delivery from domestic sources and in case of any such material available in the United States but which has not been developed commercially, the Secretary of War and the Secretary of the Navy may, if they find that the production of such material is economically feasible, direct the purchase of such material without requiring the vendor to give bond.

Sec. 6. For the procurement, transportation, maintenance, rotation, and storage of the materials to be acquired under this Act, there is hereby authorized to be appropriated the sum of $100,000,000, out of any money in the Treasury not otherwise appropriated, during the fiscal years June 30, 1939, to and including June 30, 1943, to be expended under the joint direction of the Secretary of War and the Secretary of the Navy.

Sec. 7. (a) That the Secretary of the Interior, through the Director of the Bureau of Mines and the Director of the Geological Survey, is hereby authorized and directed to make scientific, technologic, and economic investigations concerning the extent and mode of occurrence, the development, mining, preparation, treatment, and utilization of ores and other mineral substances found in the United States or its Territories or insular possessions, which are essential to the common defense or the industrial needs of the United States, and the quantities or grades of which are inadequate from known domestic sources, in order to determine and develop domestic sources of supply, to devise new methods for the treatment and utilization of lower grade reserves, and to develop substitutes for such essential ores and mineral products; to explore and develop, on public lands and on privately owned lands, with the consent of the owner, deposits of such minerals, including core drilling, trenching, test-pitting, shaft sinking, drifting, crosscutting, sampling, and metallurgical investigations and tests as may be necessary to determine the extent and quality of such deposits, the most suitable methods of mining and beneficiating them, and the cost at which the minerals or metals may be produced.

(b) For the purpose of carrying out the provisions of this section there is hereby authorized to be appropriated out of any money in the Treasury not otherwise appropriated, for each of the fiscal years ending June 30, 1940, 1941, 1942, and 1943, the sum of $500,000, of which amount $350,000 shall be appropriated to the Bureau of Mines and $150,000 to the Geological Survey.

Approved June 7, 1939.

ASSESSMENT WORK ON MINING CLAIMS FOR 1938-1939

The series of Annual Moratoriums suspending assessment work on mining claims, which began for the year ending noon July 1, 1932 ceased at noon July 1, 1938.

Congress refused to pass a bill to again relieve claim owners from the necessity of performing annual labor on their claims for the current year ending noon July 1, 1939. However, on June 30, 1939, an act was passed and approved by the President extending the time within which annual assessment work on mining claims may be commenced for the year 1938-1939, from noon July 1, 1939 to noon, September 1, 1939.

The text of the law follows:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That to comply with the provisions of section 2324 of the Revised Statutes of the United States, which requires on each mining claim located, and until a patent has been issued therefor, not less than $100 worth of labor to be performed or improvements aggregating such amount to be made each year, it shall be sufficient, for the year beginning at 12 o'clock meridian July 1, 1938, if such work or improvements are in good faith commenced on or before 12 o'clock meridian September 1, 1939, and prosecuted with reasonable diligence to completion."

It will be noted that this act requires only that the work be *commenced* before noon September 1, 1939, and continued thereafter with due diligence until completed.

NEW MINING LEGISLATION, 1939

A number of bills making changes in the mining laws were passed, and approved by the Governor at the Fifty-third session of the State Legislature which adjourned June 20, 1939.

Assembly Bill No. 1875 (Chapter 93, Stat. 1939) introduced by Mr. Scudder establishes a Public Resources Code consolidating and revising the law relating to natural resources and repealing certain obsolete acts.

There are four Divisions in the code: Division I, The Department of Natural Resources; Division II, Mines and Mining; Division III, Oil and Gas; Division IV, Forests.

Division II, Mines and Mining, comprises Chapter I, Sections 2001 to 2004, Definitions; Chapter II, Sections 2200 to 2209, The Division of Mines; Chapter III, Sections 2250 to 2274, Regulating and Licensing Purchasers of Gold or Silver Ores, Concentrates or Amalgams; Chapter IV, Sections 2301 to 2324, Manner of Locating Mining Claims, Tunnel Rights and Mill Sites; Chapter V, Sections 2351 to 2360, Mining Partnerships; Chapter VI, Sections 2401 to 2512, Placer Mining Districts; Chapter VII, Sections 2601 to 2606, Miscellaneous Provisions.

Of particular interest to the prospector and miner is **Assembly Bill No. 2865** (Chapter 1104, Stat. 1939) introduced by Mr. Redwine which amends sections 2304 and 2306 of the code, relating to the Manner of Locating Mining Claims. The text of this new act which becomes effective September 19, 1939 follows:

''The people of the State of California do enact as follows:

''Section 1. Section 2304 of the Public Resources Code is hereby amended to read as follows:

''2304. (a) Within ninety days after the date of location of any lode mining or placer claim hereafter located, the locator or locators thereof shall sink a discovery shaft upon the claim to a depth of at least ten feet from the lowest part of the rim of the shaft at the surface, or shall drive a tunnel, adit, or open cut upon the claim to at least ten feet below the surface.''

''(b) In lieu of the discovery work required by paragraph (a) of this section, the locator of a placer mining claim may, within ninety days of the date of location, excavate an open cut upon the claim, removing from the cut not less than seven cubic yards of material.''

''Sec. 2. Section 2306 of said code is hereby amended to read as follows:

''2306. The relocation of any lode or placer mining location which is subject to relocation shall be made as an original location is required to be made, except that the relocator may either sink a new shaft upon the ground relocated to the depth of at least ten feet from the lowest part of the rim of the shaft at the surface, or drive a new tunnel, adit, or open cut upon the ground to at least ten feet below the surface, or the relocator may sink the original discovery shaft ten feet deeper than it is at the time of relocation, or drive the original discovery shaft ten feet deeper than it is at the time of relocation, or drive the original tunnel, adit, or open cut upon the claim ten

feet further or, in the case of placer mining claims, relocator may either excavate a new open cut upon the claim, removing from the cut not less than seven cubic yards of material, or remove from the original open cut not less than seven additional cubic yards of material."

"Sec. 3. Section 2306.5 is hereby added to said code, to read as follows:

"2306.5 As to any placer mining claim which has been otherwise validly located or relocated since the enactment of sections 1426da and 1426dc of the Civil Code and as to which claim the locator or relocator has not performed the work thereon required by those sections for the reason that literal compliance therewith was not feasible, the locator or relocator may perfect his claim by excavating an open cut thereon and removing from the cut not less than seven cubic yards of material; provided, that such work shall be completed within ninety days after the effective date of this section."

Senate Bill No. 120 introduced by Senator Quinn is an act to amend Section 482 of the Fish and Game Code, but as it relates to the pollution of the water of the Trinity and Klamath River fish and game district by mining debris, it is of special interest to the mining industry in that area.

As amended and approved the law now reads:

"The people of the State of California do enact as follows:

"Section 1. Section 482 of the Fish and Game Code is hereby amended to read as follows:

"482. (a) It is unlawful to conduct any mining operations in the Trinity and Klamath river fish and game district between July 1, and November 30, both dates inclusive, except when the debris, substances, tailings or other effluent from such operations do not and can not pass into the waters in said district."

"(b) It is unlawful between July 1 and November 30, both dates inclusive, to pollute, muddy, contaminate, or roil the waters of the Trinity and Klamath river fish and game district. It is unlawful between said dates to deposit in or cause, suffer, or procure to be deposited in, permit to pass into or place where it can pass into said waters, any debris, substance or tailings from hydraulic, placer, milling or other mining operation affecting the clarity of said waters. The clarity of said waters shall be deemed affected when said waters at a point a distance of one mile below the confluence of the Klamath river and the Salmon river or at a point a distance of one mile below the confluence of the South Fork of the Trinity river and the Trinity river contain fifty (50) parts per million, by weight, of suspended matter, not including vegetable matter in suspension and suspended matter occurring in said stream or streams due to an act of God."

"(c) It is unlawful, between July 1 and November 30, both dates inclusive, to carry on or operate any hydraulic mine of any kind on, along, or in any waters flowing into said Trinity and Klamath river district; provided, however, nothing herein contained shall prevent the operation of a hydraulic mine where the tailings, substance, or debris, or other effluent therefrom, does not or will not pass into said waters of said Trinity and Klamath river fish and game district, between said dates, and provided further that any person, firm or corporation

engaged in hydraulic mining shall have the right until the fifteenth day of July to use water for the purpose of cleaning up.''

''(d) Any structure or contrivance which causes or contributes in whole or in part, to the condition, the causing of which is in this section prohibited, is a public nuisance, and any person, firm, or corporation maintaining or permitting the same shall be guilty of maintaining a public nuisance, and it shall be the duty of the district attorney of the county where the condition occurs or the acts creating the public nuisance occur, to bring action to abate such public nuisance.''

''(e) Any person, firm, or corporation violating any of the provisions of this section is guilty of a misdemeanor.''

9—76807

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

Mr. Frank Sanborn, mineral technologist, has been granted retirement under pension, "for disability," by the State Employees Retirement System Board, effective June 1, 1939, he having been on sick leave for some months past. He was appointed petrographer on the staff of the State Mining Bureau, September 1, 1920, and promoted May 15, 1933, with change of title to mineral technologist.

Among the interesting experiences of his many years of faithful and effective service in the testing laboratory of this Division was his identification in 1931 of a new barium mineral in a sample sent to us from Mariposa County. This new mineral was named Sanbornite in his honor by Professor Austin F. Rogers of Stanford University after detailed analyses had checked and proved that it was indeed a new and previously unknown species.

Mr. George L. Gary has been appointed mineral technologist on the staff of this Division, vice Frank Sanborn, retired. Mr. Gary received his technical training at the University of Southern California; and he assisted Dr. Adolph Pabst of the University of California in the preparation of this Division's Bulletin No. 113, "Minerals of California." He comes of a family prominently identified with the development of the country's mineral resources, among whom was the late Judge Elbert H. Gary of the United States Steel Corporation.

New Publications.

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, October, 1938, being Chapter 4 of State Mineralogist's Report XXXIV. This chapter contains: "Mineral Resources of Inyo County," with map showing locations of mines; Geology and Ore Deposits of the Darwin Silver-Lead Mining District, Inyo County; "Sulphur Deposits of Inyo County"; "Biennial Report of the State Mineralogist"; and a special article on "Sources of Gold Produced in California from 1848 to 1937."

COMMERCIAL MINERAL NOTES (Nos. 193-195 incl.) May, June, July, 1939, respectively. These 'Notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to five pages in recent months.

Mail and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum

HENRY H. SYMONS, Statistician and Curator

Tabulations are presented herein showing the complete totals for all substances produced in California during the year 1938, grouped by substances and by counties. The complete detailed annual report on the mineral production of California for 1938 will be available later as Bulletin 117 of the State Division of Mines.

SUMMARY—1938

The total value of the mineral output of California for the year 1938 was $380,444,976, being an increase of $18,929,025 over the total of 1937 which was $361,515,951. There were sixty different mineral substances, exclusive of a segregation of the various stones grouped under gems; and all fifty-eight counties of the State contributed to the list.

As revealed by the data following, the salient features of 1938 compared with the previous year were: The fuels, metals and salines groups showed increases in total value, while structural materials and industrial minerals showed a decline. Of the year's mineral production petroleum showed the greatest increase in value of output; followed in turn by gold, natural gas, potash, soda magnesium salts, iron ore, salt, pumice and volcanic ash, quicksilver and limestone; while those showing a decrease in amount and value were miscellaneous stone, brick and hollow building tile, copper, cement, silver, pottery clay, diatomite, lead, etc. Returned to the commercial after several years absence were lithia salts, and serpentine, and for the first time were added alum minerals and garnets.

Of the fuels, petroleum showed an increase in value of $20,508,471 and an increase in amount of from 238,558,562 barrels to 249,395,763 barrels of crude oil. There was no marked change in the price of crude from June, 1936. Natural gas showed an increase in value and amount from 323,883,710 M. Cu. ft. worth $19,859,865 to 332,358,439 M. Cu. ft., worth $22,310,755.

Of the metals, the gold output increased from 1,174,578 fine ounces to 1,311,129 fine ounces; and in value from $41,110,230 to $45,889,515. Quicksilver increased from 9,995 flasks worth $837,789 to 12,171 flasks worth $846,497, iron ore, platinum and tungsten concentrates also showed an increased yield with all other metals showing a decline. Silver decreased from 2,888,265 fine ounces worth $2,234,073, to 2,590,804 fine ounces worth $1,674,863 and copper from 10,512,500 pounds worth $1,272,013 to 1,613,491 pounds worth $158,122.

Of the structural materials slate, bituminous rock and limestone were the only substances to show an increased total value over the previous year, miscellaneous stone showing a decrease in total value from $16,917,683 to $11,734,038 and cement from 12,072,063 barrels worth $16,546,229 to 10,561,037 barrels worth $15,502,574. The group

as a whole showed a decline in total value from $37,976,624 to $30,880,924.

In the industrial group the total value decreased from $6,159,918 to $5,027,093. The total value of the saline group increased from $13,216,270 to $14,279,949, with all the products showing an increased value with the exception of borates.

Distribution of the 1938 output of California by substances is shown in the following tabulation:

Substance	Amount	Value	Number of properties
Bentonite	9,374 tons	$ 113,164	7
Borates	276,144 tons	5,014,237	4
Brick	----------	2,594,546	43
Cement	10,561,037 bbls.	15,502,574	10
Clay, pottery	304,564 tons	582,608	53
Coal	275 tons	1,650	3
Copper	1,613,491 lbs.	158,122	[e]10
Gems	----------	4,575	6
Gold	1,311,129 fine ozs.	45,889,515	([a])
Granite	----------	131,386	21
Gypsum	161,996 tons	327,821	5
Lead	1,003,096 lbs.	46,142	[e]15
Lime	70,578 tons	683,403	
Limestone	302,655 tons	729,149	23
Magnesium salts	24,176 tons	469,636	4
Marble [f]	----------	6,015	5
Mineral water	26,900,959 gals.	853,998	41
Natural gas	332,358,439M.cu.ft.	22,310,755	([b])
Petroleum	249,395,763 bbls.	258,354,343	([b])
Platinum	1,069 fine ozs.	35,150	[e]11
Pumice and volcanic ash	18,783 tons	105,207	16
Quicksilver	12,171 flasks	846,497	57
Salt	395,746 tons	1,099,737	12
Sandstone	----------	9,384	5
Silica (quartz and sand)	63,167 tons	278,676	6
Silver	2,590,804 fine ozs.	1,674,863	[e]54
Slate	6,871 tons	30,281	4
Soapstone and talc	28,346 tons	290,810	11
Soda	178,105 tons	2,023,610	4
Stone, miscellaneous	([c])	11,734,038	278
Tungsten	768 tons	786,860	11
Zinc	17,554 lbs.	843	[e]1
Unapportioned [d]	----------	7,755,381	([d])
Total value	----------	$380,444,976	

[a] There were 927 lode mines and 675 placer mines, not including snipers, prospectors, and various individuals who sold small lots.

[b] There was an average of 13,753 producing wells.

[c] Includes macadam, crushed rock, ballast, rubble, rip rap, sand and gravel.

[d] Includes alum (1), barite (2), bituminous rock (2), bromine (2), carbon dioxide (2), calcium chloride (2), calcium silicate (2), chromite (3), diatomite (5), dolomite (3), feldspar (2), garnets (1), Iodine (2), iron ore (3), lithia (1), magnesite (2), mica (1), potash (1), pyrite (1), sillimanite group (2), serpentine (1), sulphur (1), paving blocks (2), tube-mill pebbles (1).

[e] Included with gold.

[f] Includes onyx and travertine.

Distribution by counties for 1938 is given in the following tabulation:

County	*Value*	*Number of Mineral Products*
Alameda	$2,531,600	9
Alpine	11,123	3
Amador	3,880,444	9
Butte	2,177,265	12
Calaveras	4,357,938	10
Colusa	2,884	2
Contra Costa	2,116,285	9
Del Norte	15,997	4
El Dorado	2,207,099	12
Fresno	30,159,518	17
Glenn	60,138	2
Humboldt	97,181	8
Imperial	604,227	11
Inyo	1,583,893	19
Kern	71,528,574	17
Kings	15,410,875	4
Lake	281,098	3
Lassen	59,546	5
Los Angeles	125,027,054	23
Madera	29,916	4
Marin	189,843	4
Mariposa	1,588,861	8
Mendocino	46,378	3
Merced	2,867,501	6
Modoc	5,896	7
Mono	349,516	9
Monterey	187,144	11
Napa	637,963	9
Nevada	11,667,896	9
Orange	21,601,082	13
Placer	2,020,042	12
Plumas	878,277	7
Riverside	3,306,793	16
Sacramento	5,467,487	9
San Benito	527,192	6
San Bernardino	16,752,866	27
San Diego	535,722	14
San Francisco	33,607	5
San Joaquin	781,907	6
San Luis Obispo	242,500	13
San Mateo	2,026,217	7
Santa Barbara	10,683,722	13
Santa Clara	624,463	11
Santa Cruz	1,907,188	9
Shasta	1,791,727	10
Sierra	905,237	5
Siskiyou	1,510,815	10
Solano	431,677	4
Sonoma	232,495	6
Stanislaus	845,523	7
Sutter	28,973	3
Tehama	81,431	4
Trinity	1,493,132	6
Tulare	273,199	8
Tuolumne	1,130,263	10
Ventura	21,966,416	9
Yolo	48,232	3
Yuba	2,633,138	4
	$380,444,976	

MUSEUM

The museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral

resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20926 SULPHUR (S)--crystals, contemporaneously forming. (two specimens). From Sulphur Banks on Sulphur Creek, one mile west of The Geysers, Sonoma County, California.
Donor: Walter W. Bradley, May, 1939.

20927 Massive white TALC. From Arlotta Claim, Ibex Mountain, 15 miles west of Tecopa, Inyo County, California.
Donor: Death Valley Curley, May, 1939.

20928 GALENA in TALC. From Broadshoulder Claim, Ibex Mountain, 15 miles west of Tecopa, Inyo County, California.
Donor: Death Valley Curley, May, 1939.

20929 CHALCEDONY Nodule. From Berkeley Hills, Berkeley, Alameda County, California.
Donor: Henry H. Symons, June, 1939.

20930 ENARGITE Cu_3AsS_4—copper sulpharsenate. From Morning Star Mine, Loope, Alpine County, California.
Donor: Geo. L. Gary, June, 1939.

20931 CINNABAR (HgS)—on fracture surface of vesicular basalt, From Sulphur Bank Mine, Lake County, California.
Donor: Walter W. Bradley, June, 1939.

20932 Bragdon SLATE (carbonaceous). From Santa Maria Claim of St. Jude Group, near French Gulch, Shasta County, California.
Donor: Walter W. Bradley, June, 1939.

20933 GYPSUM—$CaSO_4.2H_2O$, a hydrous calcium sulphate. From one-half mile south of Thornton Beach, San Mateo County, California.
Donor: G. L. Bolander, June, 1939.

20934 JASPER. From Jasper Canyon, near Coalinga, Fresno County, California.
Donor: G. L. Bolander, June, 1939.

20935 FERBERITE—$FeWO_4$, an iron tungstate. From the Conger Mine, Boulder County, Colorado. Property of the Vanadium Corporation of California.
Donor: Glen O. Scogland, June, 1939.

20936 Section of OAK TRACK RAIL. From tunnel driven in 1863 (reopened 1939). Originally had strap-iron on top. Was set into dapped ties and wedged. Remarkably well preserved. Locality: Phoenix Gravel Mine, one mile northwest of Nevada City, Nevada County, California.
Donor: A. J. Grier, July, 1939.

20937 RHODONITE, a manganese silicate. From Jack Fry ranch, near Tuolumne City, Tuolumne County, California.

20938 BARITE ($BaSO_4$), a barium sulphate. From near Hoopa, Humboldt County, California.
Donor: H. C. Chester, July, 1939.

LABORATORY

George L. Gary, Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one "Minerals of California," by Adolf Pabst, was published this year by the Division of Mines as Bulletin No. 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

CORRECTIONS AND ADDITIONS TO BULLETIN NO. 113

25. Iddingsite, a hydrous magnesium and iron silicate occurs with chrysolite near Seiad Valley, Siskiyou County.
26. Mariposite, a muscovite with a characteristic green color due to the presence of chromic oxide has been reported from Imperial County.
27. Green tourmaline, a complex silicate of boron and aluminum, has been reported from Kern County.
28. Stibiconite, a hydrous antimony oxide, an alteration product of stibnite, occurs at the Stayton mine, Antimony Mountain, San Benito County.
29. Hübernite, a tungstate of iron and manganese, occurs in prismatic divergent crystals at Colorado Hill, near Loope, Alpine County.
30. Cinnabar, mercuric sulphide, occurs near Loope, Alpine County.
31. Molybdenite, a molybdenum disulphide, associated with andradite garnet, occurs in Kern County.
32. Pyrolusite, a manganese dioxide, occurs in the Panamint Range, Inyo County.
33. Alunogen, a hydrous aluminum sulphate, occurs in fibrous masses with graphite on quartzite at the P & L mine, two and one-half miles south of El Portal, Mariposa County.
34. Kyanite, an aluminum silicate, was found about seven miles northwesterly of Death Valley Junction, Armagosa Range, in Inyo County.
35. Gypsum crystals in sandstone, were found about one-half mile south of Thornton Beach, in San Mateo County.
36. Rhodonite of good quality occurs on the Jack Fry ranch, near Tuolumne, Tuolumne County.
37. Stilbite, a hydrous sodium, calcium and aluminum silicate has come from San Bernardino County.

LIBRARY

JOHN C. O'BRIEN, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, CALIFORNIA JOURNAL OF MINES AND GEOLOGY contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the state are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:

Bulletins:

Bulletin 909 B Geophysical Abstracts 93, April, June, 1938.

Topographic Maps:

Ballaret (California-Nevada)
Big Bar and Vicinity Quad.
Cima Mesa
Coalinga
Copperopolis
Corona
Dardanelles
Hall's Flat
Kaiser Quadrangle
Mt. Lowe Quadrangle
Mt. Shasta Quadrangle
Newhall Quadrangle
Oceanside (San Diego Co.)
Redlands
Rock Creek Quadrangle (Los Angeles Co.)
Santa Cruz Quadrangle
Santa Susana Quadrangle
Sonora Quadrangle
Shadow Mountains Quadrangle (Advance Sheet)
Tehipite Quadrangle

U. S. Bureau of Mines:

Information Circulars

6984R Mineral Wool, by J. R. Thoenen.
7062 Marketing of Salt, by F. E. Harris.
7063 Coal-Mine Mechanization and Accident-Frequency Rates of Hand and Mechanical Loading in Illinois, by A. U. Miller.
7064 Effect of Sulphur Compounds in the Air on Various Materials, by L. R. Burdick and J. F. Barkley.
7065 Sulphur in the Products of Combustion of Fuels, by L. R. Burdick and J. F. Barkley.
7066 Concentration of Sulphur Compounds in City Air, by L. R. Burdick and J. F. Barkley.
7067 Multiple-shift Mechanical Mining in some Bituminous Coal Mines, Progress Report 2, by Albert L. Toenges and Frank A. Jones.
7068 Requirements for Ventilation—Alabama Mining Law, by Frank E. Cash.
7069 Tin Deposits of the Black Hills, South Dakota, by E. D. Gardner.
7070 Safety Work of the Bureau of Mines and Some of Its Results, by D. Harrington.
7071 Some of the Welfare Problems of the Mining Industry and what the Bureau of Mines has done about them, by D. Harrington.
7072 Some data on dust in Industrial Work, by D. Harrington.
7073 Milling Methods and Costs at the Mount Isa Mines, Ltd., Mount Isa, Queensland, Australia, by J. Kruttschnitt, L. K. Jacobsen, and K. B. Gross.
7074 Spontaneous Combustion of Coal, by O. P. Hood.
7075 Fireproofing Mine Shafts, by Jos. R. Guiteras.
7076 Bureau of Mines Midget Impinger, by H. H. Schrenk and Florence L. Feight.
7077 Mining and Milling Methods and Costs at the Tennessee-Schuylkill Corporation Mine, Chloride, Arizona, by Jacob Schoder and Paul T. Allsman.
7078 Mine Safety Board Decision 31, Main Fan Installations at Metal Mines, by Mine Safety Board.

U. S. Bureau of Mines—Continued:

Information Circulars

7079 Coordination of Safety and Employment, by G. W. Grove.

7080 Marketing Talc, Pyrophyllite, and Ground Soapstone, by Bertrand L. Johnson.

7081 What is the Responsibility of the Coal-Mine Official in the Present Change to and Future of Mechanized Mining? by D. Harrington.

7082 Reconnaissance of Placer-Mining Districts in Lemhi County, Idaho, by S. H. Lorain and O. H. Metzger.

7083 Some Signaling Systems in Metal-Mine Shafts, by McHenry Mosier and E. J. Gleim.

Report of Investigations:

3296 R Classification Chart of Typical Coals of the United States, showing B.T.U. per pound on the moist, mineral-matter-free basis, plotted against fixed carbon on the dry, mineral-matter-free basis, by A. C. Fieldner, W. A. Selvig, and W. H. Frederic.

3441 Volumetric Determination of Molybdenum, by C. E. Arrington and A. C. Rice.

3442 Analyses of Crude Oils from Some Fields of Oklahoma, by O. C. Blade.

3443 Explosion and Fire Hazards of Combustible Anesthetics, By G. W. Jones.

3444 Measurement of Pressures on Rock Pillars in Underground Mines, by Leonard Obert.

3445 Effect of Acid Treatment upon the Ultimate Recovery of Oil from some Limestone Fields of Kansas, by R. E. Heithecker.

3446 Accidents in the Petroleum Industry of Oklahoma in 1937, summarized and compared with 1923, by C. F. McCarroll.

3447 Bit Gage v. Drilling Speed, by McHenry Mosier and Wing G. Agnew.

3448 Classification and Tabling of Table Middlings at the Colta Coal Washery, Flat Creek, Ala., by B. W. Grandrud, G. D. Coe, and H. J. Hager.

3449 A Washability Study of the Woodstock Coal Bed at Klondyke Mine, West Blockton, Ala., by B. W. Grandrud and G. C. Coe.

3450 A Washability study of the Black Creek Coal Bed at Yolande No. 6, Rockcastle, Ala., by B. W. Grandrud, G. D. Coe, and J. C. Mead.

3451 Expansion of Coal during Coking, By H. S. Auvil, J. D. Davis, and J. T. McCartney.

3452 Studies of Roof Movement in Coal Mines. 2. Crucible Mine of the Crucible Fuel Co., by E. R. Maize and H. P. Greenwald.

3453 Relative Air Dustiness During Cycle of Operations at Mount Weather Testing Adit, by John A. Johnson and Wing G. Agnew.

3454 Annual Report of the Explosives Division, Fiscal Year 1938, by Wilbert J. Huff.

3455 Cooperative Fuel Research Motor-Gasoline Survey, Winter 1938-1939, by E. C. Lane.

MC 38 Some Suggestions on Safety in Timbering Anthracite Mines.

Technical Papers

8 Methods of Analyzing Coal and Coke.

593 Allaying Dust in Bituminous Coal Mines with water.

Bulletin 279 Limits of Inflammability of Gases and Vapors.

414 Coal Mining in Europe.

Books

Gems and Gem Materials by Edward H. Kraus and Chester B. Slawson.

Year Book of the American Bureau of Metal Statistics—19 Annual Issue, 1938.

Source Book in Geology, by Kirtley F. Mather and Shirley L. Mason.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

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GEORGE D. NORDENHOLDT, Director

DIVISION OF MINES
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WALTER W. BRADLEY — State Mineralogist

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MARIPOSA
REDWOOD CY
SAN MATEO
SAN JOSE
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
HOLLISTER
SAN BENITO
SALINAS
MONTEREY
FRESNO
INDEPENDENCE
I N Y O
DEATH VALLEY
VISALIA
TULARE
HANFORD
KINGS
TULARE LAKE
PORTERVILLE
SAN LUIS OBISPO
BAKERSFIELD
K E R N
S A N B E R N A R D I N O
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
R I V E R S I D E
SANTA ANA
ORANGE
SAN DIEGO
IMPERIAL
EL CENTRO
·LEGEND·
Mining Division Boundaries.
Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

CHAS. VOLNEY AVERILL, Mining Engineer

There is no report from the Redding Field District on account of unfinished field work.

SACRAMENTO FIELD DISTRICT

C. A. LOGAN, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. LAIZURE, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field District are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

W. B. TUCKER and R. J. SAMPSON, Mining Engineers

On account of unfinished field work there is no report from the Los Angeles Field District in this issue.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

WHERE TO LOOK FOR NEW DEPOSITS OF MINERALS

The concentration of some one kind of mineral to form a deposit of sufficient quantity to be worthy of mining at a profit generally means a certain coincidence of several unusual or usual happenings in nature. The way and sequence in which these happenings occurred, if they are correctly understood, constitute the prospector's or geologist's key to exploration. The oil and gas industry, for example, has reached its mammoth proportions principally because geologists worked out this key and indulged in its use.

We know only imperfectly how most mineral deposits came to be so concentrated in only limited areas. The goal is to find out more about this problem through careful study of the geological features involved. In so doing we may apply this knowledge to the exploration for new deposits.

Mineral deposits often seem prone to occur in more or less definite zones. In some cases, these zones prove to be definitely related to geologic structure, faults, fracture planes or the like. To know where these zones occur is one of the first steps to finding orebodies. This applies not only to the particular mineral claim prospected, but to larger regional areas.

For the purpose of assisting those engaged in searching for new deposits of valuable minerals, the Geologic Branch is preparing a series of economic mineral maps of California. Not only are the producing mines to be shown, but all the known deposits, so that major mineralized zones or trends in mineralization will be clearly delineated. A map showing only the deposits which have in the past proved to be of commercial value, falls far short of a help to one who is looking for something new. In preparing these maps, the locations of the mineral deposits are placed on the same base map as that used for showing the geology of the state; the geological formation boundaries and major faults remain on the base and serve as a guide to the significant position of the mineral deposits.

The first of these economic mineral maps of California has recently been published by the Division of Mines, i.e., No. 1 Quicksilver. In this October, 1939, issue of the California Journal of Mines and Geology, is a report by Alfred L. Ransome and John L. Kellogg on the "Quicksilver Resources of California" which should be read in conjunction with the quicksilver map. The report represents the results of graduate study at Stanford University, in cooperation with the Division of Mines.

The Geologic Branch is following a plan of assembling all salient factual data of state-wide scope concerning the geology and mineral

deposits of California. The quicksilver map and report show one unit of progress along this line, supplementing earlier units of work: (a) Geologic Map of California, 1938; (b) Bibliography of the Geology and Mineral Resources of California (Bulletins 104, 115, and July 1939 issue of the Journal); and (c) Minerals of California, Bulletin 113. Work now in progress consists of state-wide maps and reports on chrome and manganese, and a bulletin and map of the "Geological Formations and Economic Development of the Oil and Gas Fields of California." In all of this work, as in the more detailed reports, the Geologic Branch continues to receive the whole-hearted and unselfish support of the highest authorities in the technical field. For this support we are duly appreciative.

QUICKSILVER RESOURCES OF CALIFORNIA*

By Alfred L. Ransome † and John L. Kellogg ‡

OUTLINE OF REPORT

* This report represents the results of a thesis prepared at Stanford University for the Degree of Engineer, 1938.

† Member of staff, Geologic Branch, California State Division of Mines, San Francisco, California.

‡ Mine Superintendent, Delgold Corporation, Jamestown, California.

MINES AND PLANTS, ALPHABETICALLY BY COUNTIES—Continued

ABSTRACT

California, through a period of almost 90 years, has been the leader in the quicksilver mining industry in the United States; from 1850 to 1939, there has been produced in this State approximately 2,400,000 flasks of quicksilver having a total value in excess of $117,000,000.

The demand for quicksilver during the last decade (1929-1939) has reached a more nearly constant level than heretofore owing to increased usefulness of the metal where it is indispensable to many forms of modern mechanical, electrical, and chemical industry. Aside from general commercial uses, quicksilver is important in time of war and is listed by the National Government as a strategic mineral.

The average annual price received per flask has fluctuated over a wide range from below $30 to over $120 during the 90 year period from 1850 to 1939; but at the present time (1939), a minimum price of $65 to $70 is considered the least that can enable the larger quicksilver operators to mine profitably. Improved methods of mining and reduction have resulted in lower costs; but material and labor are above former standards. Most important of all, the general grade of mined ore is lower: from 5 to 10 pounds of quicksilver per ton.

The principal quicksilver ore deposits of California occur in the Coast Ranges within a belt about 400 miles long having a maximum width of 75 miles. Most of these deposits occur in the fracture planes of basic igneous rocks (especially serpentine) and their associated sediments belonging to the Jurassic Franciscan formation; the time of deposition of the ore minerals appears to be a late epoch—late Pliocene, Pleistocene, and Recent.

Quicksilver deposits are considered to be epithermal (deposition taking place near the surface of the earth's crust), occurring as impregnations, vein fillings, and as fissure and breccia fillings usually associated with volcanic rocks and hydrothermal activity.

The association of quicksilver deposits with the Franciscan formation and especially the serpentine is probably structural, not genetic; fracturing afforded channel ways for the passage of ascending solutions to favorable zones of precipitation. These zones are in interstitial spaces of porous, or brecciated, rock masses underlying relatively impervious material.

Cinnabar, the most important ore-mineral of quicksilver, is commonly associated with marcasite and pyrite, and with calcite, barite, quartz, chalcedony, and opal, as gangue minerals. Cinnabar is deposited from hot alkaline solutions and the source of the contained metal is considered to be from a deep-seated rock magma, the existence and position of which is only a conjecture.

There is no method by which an accurate numerical determination can be made of the ore reserves of quicksilver. From the review of about 120 mines in 23 counties in California that have produced quicksilver, as well as many potentially productive prospects and claims in these as well as other counties, it is evident that quicksilver mineralization is widespread in the State.

There have been no new dscoveries of quicksilver orebodies of major importance in California for many years, and the principal mining activities have been confined to working the lower grade ores in the existing mines. Although the known ore reserves in California are diminishing, there is every reason to believe that unknown reserves remain, the development of which will prolong the life of the quicksilver mining industry here for many years.

INTRODUCTION

Purpose and Scope

Beginning in January, 1938, a period of five months was spent in compiling the thesis which is the basis for the present report. During this period nearly every operating quicksilver mine in California was visited. To supplement the first-hand knowledge thus gained, a careful search was made through the past unpublished records of every quicksilver mine in the State. Also many personal interviews were held with nearly every person who is professionally active in the quicksilver industry in California.

The present report covers to some extent the past, but principally reviews the present status of the economics, geology, and mines and plants of the quicksilver industry. In this respect it is hoped that the gap of 21 years since the work of W. W. Bradley was published [1] has been bridged sufficiently to the present day. It is further hoped that the results of this work may form a basis for additional studies of other strategic minerals.

Only a limited attempt at originality has been made in the geological phase. Recent geological reports have been drawn upon for information, together with such material as could be found applicable from the older publications.

Descriptions of operating mines are for the most part the result of personal observations in the field. The data on properties now abandoned or idle are compiled from former publications.

Discussion of the metallurgical phase of the industry has been limited to a short description of the modern types of mechanical installations, now being used for the reduction of quicksilver ores, under the heading of the individual mines.

Acknowledgments

The study of the quicksilver resources of California was first suggested to the authors as a possible thesis subject of interest and value by Mr. Charles A. Dobbel, of the Department of Mining Engineering at Stanford University. It was under his supervision that this work was carried on. The helpful suggestions, and constructive criticisms given by Professor Dobbel, and by Professor Frederick G. Tickell, executive head of the Department of Mining Engineering, during the writing of the original thesis are deeply appreciated.

The members of the staff of the State Division of Mines have cooperated with the writers to the fullest extent. Special thanks are due Mr. Walter W. Bradley, State Mineralogist; Dr. Olaf P. Jenkins, Chief Geologist; and Mr. Henry H. Symons, Statistician and Curator, for their constant assistance and interest in many phases of this work.

The writers are indebted to Mr. Charles W. Merrill, Economic Branch of the United States Bureau of Mines (San Francisco office), for his aid in obtaining necessary statistical data.

[1] Bradley, W. W., Quicksilver resources of California: Cal. State Min. Bur., Bull. 78, 1918.

Many men professionally interested in the quicksilver industry have kindly contributed a wealth of information which has been of inestimable help. Mr. Henry W. Gould placed at the disposal of the writers all the general information at his command. Mr. C. N. Schuette has been a constant source of information in regard to the industry as a whole, and to the geological phase in particular. Mr. Irving Ballard, and Mrs. V. R. Ghinsberg, furnished the writers with data on several quicksilver properties. Mr. Ballard also aided in the preparation of the economic section of this report. Mr. Worthen Bradley was kind enough to furnish valuable data pertinent to the quicksilver mines under his control.

The authors wish to acknowledge the uniform courtesy and hearty cooperation extended to them by the various mine owners, operators, and company officials who were approached during the course of investigation.

HISTORY AND ECONOMICS

History of Quicksilver in California

The early history of quicksilver mining in California is not without its romance and interest. The spectacular rise to fame of the New Almaden Mine, the uncertain history of the discovery of the New Idria, the accidental discovery of the Knoxville (Redington), and Mirabel (Bradford) mines, and other incidents, all tend to make the story of quicksilver compete in interest with that of gold.

As early as 1824, the New Almaden deposits near San Jose were known to the early Spanish settlers who attempted to extract gold and silver. However, it was not until 1845 that it was discovered that the deposit was quicksilver ore; mining for that metal was started on a large scale the following year. For nearly 20 years from 1850, the total quicksilver production record for the new State of California was practically the production record for this one mine. Historical records of the discovery of the New Idria Mine, the second largest quicksilver mine (to the New Almaden) in California, are apparently lost, but the mine was in operation in 1854, and is still producing.

The gold rush of the '50's was primarily responsible for a tremendous increase in the production and use of quicksilver, the principal source of which was the New Almaden and to a small extent the New Idria during the latter part of this 10-year period. The interest of prospectors was aroused to the possibilities of new cinnabar deposits, and during this decade, the St. Johns, Aetna, and Guadalupe mines were discovered, as well as many smaller properties. Only the Guadalupe recorded any production.

Between 1860 and 1870, quicksilver mining spread to other districts of the State, the stimulus being the use of the metal in hydraulic gold mining in California, and gold mining boom on the Comstock lode. During these years, the Knoxville (Redington) and the Manhattan (Lake) mines of the Knoxville district were discovered. By sheer accident a road gang, excavating for a grade, ran across the extensive cinnabar deposits where the once important Knoxville mine is located. The Sulphur Creek district was opened up with the discovery of the Abbott mine in east-central Lake County in 1862, and the Manzanita

mine in 1865, but the district did not have a history of large production. Prospectors at work in the southern part of the State discovered quicksilver early in 1860, in the Los Prietos district, north of Santa Barbara. The cinnabar deposits of San Luis Obispo County were noted by prospectors as early as 1861. The usual rush of miners followed the first location and within a few years many claims were established in the Santa Lucia Range north of San Luis Obispo. Very little quicksilver was produced until the middle '70's, and then principally from the Oceanic and Klau (Sunderland) mines.

During the great production years from 1874-1878, mines were opened up in all sections of the State. The Mayacmas district, covering parts of Lake, Napa, and Sonoma counties, was being combed by prospectors and many mines began producing. Among these were the Great Western, the Culver-Baer, the Cloverdale, the Oat Hill, the Aetna, and the Helen. It was during this period that the California Borax Company, operating the Sulphur Bank mine for the extraction of sulphur, decided to exploit the cinnabar which had been giving them so much trouble in their operations. This brought about the greatest era of production for the Sulphur Bank mine. The Knoxville, Guadalupe, St. Johns, and Altoona, as well as many other smaller mines, then reached an all-time high in production.

In 1886 or 1887, an early Lake County settler named Bradford stumbled across cinnabar float in St. Helena Creek, about four miles south of Middletown. Subsequent investigation lead to the discovery and exploitation of what is now known as the Mirabel Mine.

With the exception of the Corona mine in the Oat Hill district, which was discovered in 1895, there have been no important new deposits of cinnabar opened up for exploitation in California since that date.

Summary of California Production and Prices

The production of quicksilver in California, in so far as recorded figures are available, dates from 1850. From that time to the end of 1938, the total number of flasks of quicksilver produced from California mines amounts to a little less than 2,400,000, having a value in excess of $117,000,000. Comparison with the total production of the United States to date shows that California can be credited with about 92% of all the quicksilver produced in this country.

Mining for quicksilver in California and in the United States began at New Almaden about 1850. During the following few years a number of other mines were developed, but the New Almaden surpassed them all, and the yearly total production from that famous property was almost identical with the production from the entire State until 1865. In this year the New Almaden produced 47,195 flasks of quicksilver as compared with 53,000 total for all the mines.

The greatest impetus to this large production was placer gold mining in California which used quicksilver for amalgamation of gold in the miner's pans, rockers, and 'long Toms.'

The period from 1868 to 1874 witnessed a drop in production caused by the general decrease of high-grade ore reserves and the fact that no suitable metallurgical method of handling low-grade ore had yet been developed.

TABLE 1. -- CALIFORNIA QUICKSILVER PRODUCTION - PRICE-VALUE STATISTICS. 1850 - 1899 INCLUSIVE

Year	New Almaden	New Idria	Knox-ville	Aetna	Oat Hill	Sulphur Bank	Great East.	Guada-lupe	Great West.	St. Johns	Altoona	Oceanic	Culver-Baer	Reed
1850....	7,723	(1)												
1851....	27,779													
1852....	15,901									(1)				
1853....	22,284													
1854....	30,004			(1)										
1855....	29,142													
1856....	27,138							(1)						
1857....	28,204							(4) 1175						
1858....	25,761	(2)												
1859....	1,294	(2)												
1860....	7,061	(2)												
1861....	34,429	(2)												
1862....	39,671	(2)	(1) 144											
1863....	32,803	(2)	852											
1864....	42,489	(2)	1,904	800										
1865....	47,194	(2)	3,545									(1)		
1866....	35,150	6,525	2,254					(4) 1654						
1867....	24,461	11,493	7,862											
1868....	25,628	12,180	8,686	1,122										
1869....	16,898	10,315	5,018	1,580										
1870....	14,423	9,888	4,546	1,220										(1)
1871....	18,568	8,180	2,128	1,970							(1)			
1872....	18,574	8,171	3,046	1,830										
1873....	11,042	7,735	3,294	1,955		(1)			(1) 340	1,800				995
1874....	9,084	6,911	6,678	1,645		573		(5)	1,122	1,900	(7)		(1) 307	1,500
1875....	13,648	8,432	7,513	1,940		5,372	(1) 412	3,342	3,384	2,100	533		1,200	1,500
1876....	20,549	7,272	9,183	300	(1) 573	8,367	387	7,381	4,322	1,683	1,979	2,358	2,150	965
1877....	23,996	6,316	9,399	1,060	2,229	10,993	505	6,241	5,856	1,463	1,317	2,575	1,395	1,516
1878....	15,852	5,138	6,686	1,075	3,049	9,469	1,366	9,072	4,963	802	1,534	1,679	1,615	1,640
1879....	20,514	4,425	4,516	1,325	3,605	9,249	1,455	15,540	6,333	1,290	1,919	779	1,505	1,110
1880....	23,465	3,209	2,139	275	4,416	10,706	1,279	6,670	6,442	492	245		166	422
1881....	26,060	2,775	2,194		(3)5,552	11,152	1,065	5,228	6,241					
1882....	28,071	1,953	2,171		(3)6,842	5,014	2,124	1,138	5,179					
1883....	29,000	1,606	1,894		(3)5,890	2,612	1,669	84	3,869					
1884....	20,000	1,025	881	2,931	1,376	890	332	1,179	3,292					
1885....	21,400	1,144	385	1,309	2,197	1,296	446	35	3,469					
1886....	18,000	1,406	409	3,478	1,769	1,449	735		1,949					
1887....	20,000	1,890	673	2,694	2,880	1,490	689		1,446					
1888....	18,000	1,320	126	959	4,065	2,164	1,151		625					
1889....	13,100	980	812		4,590	2,283	1,345		556					
1890....	12,000	977	505	931	2,498	1,608	1,064		1,334		240			
1891....	8,200	792	442	849	3,605	1,375	1,660		1,844					
1892....	5,563	848	728	1,592	5,680	1,393	1,630		5,867					
1893....	6,614	869	1,012	3,795	6,120	1,200	1,445		3,187					
1894....	7,235	1,005	1,209	3,575	4,930	348	1,368		5,341					
1895....	7,050	1,100	163	3,300	5,400	2,703	1,813		5,023		3,926			
1896....	6,200	1,335	1,906	3,800	5,000	1,236	1,126		2,303		4,205			
1897....	4,700	3,605	1,550	3,600	6,200		1,538		2,709		838			
1898....	5,875	5,000	1,012	3,450	6,850		1,704		1,150		4,032			
1899....	4,435	4,780	882	3,800	5,850	336	2,119		1,545		3,076			

Year	Klau (Carson)	Clover-dale	Abbott	Man-hattan	Corona	Mirabel	Helen	Cambria	Socrates	Manza-nita	Other Mines	Total Flasks	Ave.Price Per Flask	Total Value in Dollars
1850....												7,723	$99.45	$768,052
1851....												27,779	66.93	1,859,248
1852....											4,099	20,000	58.33	1,166,600
1853....												22,284	55.45	1,325,648
1854....												30,004	55.45	1,663,722
1855....											3,858	33,000	53.55	1,767,150
1856....											2,862	30,000	51.65	1,549,500
1857....												28,204	48.73	1,374,381
1858....											5,239	31,000	48.83	1,482,730
1859....											11,706	13,000	61.13	820,690
1860....											2,939	10,000	53.55	535,500
1861....									(1)		571	35,000	42.05	1,471,750
1862....			(1)	(1)							1,885	42,000	36.35	1,526,700
1863....											6,876	40,531	42.08	1,705,544
1864....											2,286	47,489	45.90	2,179,745
1865....										(1)	2,261	53,000	45.90	2,432,700
1866....											2,621	46,550	53.13	2,473,202
1867....											3,184	47,000	45.90	2,157,300
1868....	(1)										112	47,728	45.90	2,190,715
1869....												33,811	45.90	1,551,925
1870....												30,077	57.38	1,725,818
1871....											840	31,686	63.10	1,999,387
1872....		(1)										31,621	65.93	2,084,773
1873....							(1)(4)128				481	27,642	80.33	2,220,482
1874....				(6)								27,756	105.18	2,919,376
1875....	1,500	714		437							1,000	50,250	84.15	4,228,538
1876....	1,570	1,028	1,436	976			(4) 250				2,595	75,074	44.00	3,303,256
1877....	735	1,291	836	439							1,234	79,396	37.30	2,961,471
1878....	472	116									158	63,880	32.90	2,101,652
1879....		18									101	73,684	29.85	2,194,674
1880....												59,926	31.00	1,857,706
1881....		208									376	60,851	29.83	1,815,185
1882....											241	52,732	28.23	1,488,624
1883....											101	46,725	28.75	1,343,344
1884....											7	31,913	30.50	973,347
1885....											392	32,073	30.75	986,245
1886....											786	29,981	35.60	1,064,326
1887....						(1)1,543					455	33,760	42.38	1,430,749
1888....						3,848					922	33,250	42.50	1,413,125
1889....						1,874					924	26,464	45.00	1,190,880
1890....						1,290					497	22,926	52.50	1,203,615
1891....						1,686					2,451	22,904	45.25	1,036,406
1892....			672	612		3,208					200	27,993	40.71	1,139,595
1893....			133	578		5,211						30,164	36.75	1,108,527
1894....			1,176			4,229						30,416	30.70	934,000
1895....	20		1,230	455	(1)	3,900						36,104	37.04	1,337,131
1896....	101		1,200	598	107	1,114					534	30,765	34.96	1,075,449
1897....	101		475	453	478	375					69	26,691	37.28	993,445
1898....	370		500	790	266	49					44	31,092	38.23	1,188,626
1899....	340		500	542	622	543					84	29,454	47.70	1,405,045

(1),(2),(3),(4) (5),(6),(7) See footnotes on next page.

TABLE II. -- CALIFORNIA QUICKSILVER PRODUCTION - PRICE - VALUE STATISTICS. 1900 - 1936 INCLUSIVE

Year	New Almaden	New Idria	Knox-ville	Aetna	Oat Hill	Sulphur Bank	Great East.	Guada-lupe	Great West.	St. Johns	Altoona	Oceanic	Culver-Baer	Reed
1900....	4,610	3,990	1,816	1,945	4,550	....	....	....	....	....	(10)	....	(10)	....
1901....	4,260	4,800	1,545	228	4,800	....	1,607	960	....	....	(10)	120	(10)	....
1902....	4,835	7,225	1,950	....	3,900	110	1,111	764	1,760	(10)	(10)	497	(10)	....
1903....	4,770	8,150	1,730	290	4,850	....	1,103	800	1,636	....	(10)	1,077	(10)	....
1904....	3,280	8,400	913	45	4,400	....	1,965	609	1,765	(10)	(10)	1,910	(10)	....
1905....	2,388	7,650	223	....	4,145	....	1,785	300	1,065	(10)	(10)	2,155	(10)	....
1906....	2,881	7,200	....	....	2,130	....	1,000	311	1,052	(10)	(10)	....	(10)	....
1907....	2,310	7,675	....	....	2,440	....	....	....	770	(10)	(10)	596	(10)	....
1908....	2,240	9,600	....	....	2,320	....	....	....	404	(10)	(10)	402	(10)	....
1909....	1,920	8,900	....	....	1,605	....	....	1,777	455	....	(10)	242	....	....
1910....	1,638	10,800	....	50	500	....	....	2,400	765	....	(10)	310	(10)	....
1911....	2,533	9,750	140	....	....	....	....	5,000	387	....	(10)	190	(10)	....
1912....	2,595	9,600	120	167	....	....	....	6,100	27	....	(10)	600	(10)	....
1913....	994	6,550	....	88	75	....	....	1,413	....	(10)	....	1,256	....	(10)
1914....	1,400	6,400	....	50	100	....	....	1,000	....	(10)	....	1,400	....	....
1915....	1,470	6,250	40	104	272	192	51	2,910	2	(10)	....	1,213	(10)	(10)
1916....	2,447	10,835	60	500	270	60	213	1,569	20	(10)	(10)	1,014	(10)	....
1917....	2,821	11,000	....	224	134	342	925	3,100	....	(10)	(10)	1,395	(10)	(10)
1918....	2,501	10,700	....	1,028	54	1,040	458	1,476	....	(10)	(10)	1,580	(10)	....
1919....	2,396	7,400	....	....	640	....	45	616	....	(10)	....	1,286	(10)	....
1920....	2,551	3,870	....	....	258	....	....	342	....	....	(10)	1,177	....	....
1921....	2,709	....	....	15	....	....	....	....	....	....	(10)	....	....	....
1922....	2,314	....	68	15	....	....	....	48	....	....	....	....	....	....
1923....	2,681	1,950	....	....	150	....	....	....	....	(10)	....	....	....	....
1924....	2,147	4,665	....	....	....	....	....	....	....	....	....	....	....	....
1925....	973	6,084	....	70	....	....	....	....	....	....	....	....	....	....
1926....	....	5,175	....	300	....	....	....	....	....	....	....	....	....	....
1927....	....	4,359	38	702	23	185	....	....	....	....	....	465	....	....
1928....	(8)	3,700	534	....	50	1,111	....	....	....	....	....	395	....	....
1929....	(8)	3,565	737	877	132	1,529	....	....	....	....	(10)	922	....	....
1930....	(8)	4,940	970	....	478	1,514	....	....	....	(10)?	(10)	995	....	....
1931....	(8)	4,000	649	230	572	2,221	....	....	215	....	(10)	1,588	(10)	....
1932....	(8)	481	13	407	75	91	....	(9)	619	....	(10)	1,102	(10)	....
1933....	(8)	377	21	196	434	1,143	....	(9)	223	....	(10)	....	....	....
1934....	(8)	595	74	324	1,127	1,951	....	(9)	386	....	(10)	946	(10)	....
1935....	(8)	562	38	234	812	2,495	....	....	339	....	(10)	1,811	(10)	....
1936....	(8)	435	12	49	340	2,437	....	(9)	327	(10)?	(10)	1,888	(10)	....
**Total	1,039,996	*358,233	120,038	66,298	*142,802	109,699	40,690	* 87,405	101,878	17,231	30,423	35,923	11,147	9,681

Year	Klau (Carson)	Clover-dale	Abbott	Man-hattan	Corona	Mirabel	Helen	Cambria	Socrates	Manza-nita	Other Mines	Total Flasks	Ave. Price Per Flask	Total Value in Dollars
1900....	....	....	....	....	(10)	....	....	....	....	....	5,461	22,372	$44.94	$1,005,397
1901....	600	300	....	(10)	(10)	....	....	....	(10)	....	2,839	22,059	48.46	1,068,979
1902....	2,400	100	(10)	(10)	(10)	318	100	....	(10)	(10)	4,129	29,199	43.20	1,261,397
1903....	3,000	340	(10)	(10)	(10)	317	175	(1)	(10)	(10)	3,732	31,995	42.25	1,351,789
1904....	2,400	272	....	(10)	(10)	....	172	....	(10)	(10)	2,774	28,993	37.62	1,090,717
1905....	1,335	283	....	(10)	....	....	125	....	(10)	(10)	2,276	23,985	35.94	862,021
1906....	....	220	....	....	....	....	....	....	(10)	....	1,557	16,404	36.50	598,746
1907....	400	244	....	....	....	....	24	(10)	....	(10)	2,308	16,800	38.16	641,088
1908....	65	....	....	....	....	....	699	....	(10)	(10)	1,106	16,927	42.33	716,520
1909....	25	....	....	....	....	....	609	....	(10)	(10)	576	16,109	47.71	768,560
1910....	....	....	....	....	....	....	276	(10)	(10)	....	588	17,387	45.23	786,414
1911....	12	14	....	....	....	....	534	....	....	(10)	132	18,742	46.01	862,894
1912....	12	140	....	....	....	....	170	....	....	....	563	20,600	42.04	866,024
1913....	....	12	....	....	....	....	320	....	....	....	577	11,285	40.23	453,996
1914....	....	....	....	....	....	....	....	....	....	....	250	10,600	49.05	519,930
1915....	115	50	....	....	....	11	264	(10)	....	....	1,412	14,164	81.52	1,154,649
1916....	....	600	(10)	(10)	(10)	....	913	(10)	....	....	2,629	21,394	93.50	2,000,339
1917....	100	999	(10)	....	....	....	500	....	(10)	....	2,216	24,256	98.29	2,384,122
1918....	....	1,267	(10)	....	....	....	290	....	(10)	....	1,797	22,536	114.03	2,569,780
1919....	....	1,319	(10)	....	....	....	180	....	....	....	1,270	15,205	89.04	1,353,853
1920....	47	851	....	....	....	....	338	....	....	....	687	10,121	75.45	763,629
1921....	....	275	....	....	....	....	15	....	....	....	42	3,056	44.56	136,175
1922....	....	854	....	....	....	....	28	....	....	....	138	3,465	55.35	191,788
1923....	....	522	....	....	....	....	10	....	....	....	135	5,448	60.98	332,219
1924....	27	855	....	....	....	....	214	....	....	....	30	7,938	68.33	542,404
1925....	....	350	....	....	....	....	....	....	....	....	206	7,683	80.81	620,863
1926....	....	....	....	....	....	....	9	....	....	....	405	5,889	87.64	516,112
1927....	5	368	(10)	(10)	....	....	....	....	....	....	193	6,338	111.67	707,764
1928....	39	686	....	....	....	40	45	....	....	....	505	7,105	118.84	844,358
1929....	55	714	....	....	....	....	50	....	....	(10)	1,286	9,867	117.78	1,162,135
1930....	54	560	....	....	....	70	....	....	....	(10)	1,860	11,451	110.36	1,263,732
1931....	20	368	....	....	....	470	....	....	....	(10)	3,035	13,418	83.22	1,116,646
1932....	107	133	....	....	....	196	5	(10)	(10)	(10)	1,762	5,125	52.30	268,037
1933....	211	103	....	....	....	145	14	(10)	....	(10)	1,101	3,976	55.94	222,417
1934....	221	256	....	....	....	1,053	67	....	....	(10)	735	7,756	67.22	521,358
1935....	579	45	....	....	....	1,065	149	....	....	....	955	9,104	67.23	612,062
1936....	644	64	....	(10)	....	969	34	....	....	....	1,295	8,587	76.62	657,936
**Total	*16,750	16,549	10,361	*7,586	4,626	33,524	*6,329	1,813	3,724	2,388	***88,541	2,360,692		$115,512,249

Explanatory:
(1) Year when mine first noted.
(2) 17,455 flasks, 1858-1865 entered under "Other Mines".
(3) Unknown part of output from Aetna Mine.
(4) Rate of production
(5) 20,000 flasks prior to 1875 under "Other Mines"
(6) 3,595 flasks prior to 1875 under "Other Mines"
(7) 1,000 flasks prior to 1875 under "Other Mines"

(8) Production from New Almaden dumps; 1133 flasks, 1928-1936, entered under "Other Mines".

(9) Production from Guadalupe dumps; 121 flasks, 1932,33,34,36, entered under "Other Mines".

(10) Mine produced; number of flasks entered under "Other Mines".

* Total output of New Idria claimed to be approx. 400,000
Total output of Oat Hill claimed to be approx. 160,000
Total output of Guadalupe claimed to be approx. 110,000
Total output of Abbott claimed to be approx. 31,000
Total output of Manhattan claimed to be approx. 16,000
Total output of Klau claimed to be approx. 29,000
Total output of Helen claimed to be approx. 16,000

** The total for each mine excludes all figures for those years that are indicated as being under "Other Mines", with the exception of those marked (10).

*** Total production from "Other Mines", excluding those marked (10) in this table.

Sources of Statistical Data:
1850-1899: U.S.Bur.Mines Bull.335,pp.139-142,1931 (Total production from Cal.Div.Mines Bull. 114)
1900-1928: Statistical records on file, Cal.Div. Mines. (1914 figures from data compiled by Lewis Eddy)
1929-1936: Data compiled by H.H.Symons, Cal.Div. Mines.

All annual production statistics for individual mines are published by permission of the owners and operators.

The invention and successful use of the Scott fine-ore furnace at New Almaden in 1874, the wide-spread use of the pan-amalgamation process for the treatment of gold ores, and the boom in hydraulic mining were the chief contributing factors to the greatest production period in California history, from 1874 to 1879. During these years mines were opened up in all sections of the State, but principally in Lake, Napa, and Sonoma Counties. The total production recorded from all mines for the peak year 1877 was just short of 80,000 flasks.

This tremendous supply exceeded the demand with a consequent sharp price drop and production decline. With but slight fluctuations both production and price remained at this lower level until the advent of the World War (1914). Production for the years from 1885 to 1914 averaged from 18,000 to 20,000 flasks annually.

Since the turn of the century, discoveries in Texas, Oregon, Nevada, Washington, Utah, Arizona, and more recently, Arkansas, have added to the general production total of the United States. Notwithstanding a steadily increased output from these States, the annual production from California during the last decade has averaged about 50% of the annual total from the entire country.

For the duration of this country's participation in the World War (1917-18), quicksilver being a strategic mineral, the Government classed the mines with munitions plants and the larger and more important ones were given military protection. The demand was abnormal, but regardless of this fact, and the sharp rise in price, the condition of the industry was one of instability. Production was a necessity, the metal being indispensable, and the producers used all available ore in sight, crowding existing plants to capacity in order to fill the demand. During the later war years, production from California averaged better than 20,000 flasks annually, a truly remarkable record under such adverse conditions.

Mining of the available ore reserves with no development for future needs resulted in a near exhaustion of supply. Consequently the condition of the quicksilver mines and the industry in general was very poor for the years immediately following 1918, and by 1921 production fell to the lowest point in the history of the State with only 3,157 flasks recorded for that year.

Since the post-war depression, California production has gradually been increasing, although adversely affected by the depression years of 1933 and 1934, but has as yet not regained the pre-war levels. For the past 15 years the average has been slightly less than 8,000 flasks annually.

Tariff History:

The history of tariff rates displays an attempt, on the part of the Federal Government, to arrive at a fair basis for the protection of the quicksilver industry in this country against an influx of more cheaply produced metal from foreign sources.

The first duty on imported quicksilver was a 10% *ad valorem* tariff imposed by the Congressional Act of 1883. This changed in 1890 to the specific rate of 10 cents per pound of metal. The acts of 1894, 1897, and 1909 fixed the rate at 7 cents per pound. In 1913 the rate was again changed, back to the original 10% *ad valorem.* The last

quicksilver tariff was placed in effect in 1922, at which time the rate was established at 25 cents per pound.

Price:

The price obtained for a flask of quicksilver is generally based upon New York metal market quotations, less freight. In the United States, from 1850 to date, the average annual price per flask has varied from $28 to $118. During the World War (1914), quotations approaching $300 per flask were recorded, but very few sales were made at that price.

Rises in price are caused by the demand increasing faster than quicksilver can be supplied. This stimulus to mining results in overproduction with a consequent price drop. The high-price periods of 1850, 1859, 1874, 1890, 1899, the World War period, and 1928 were each followed by a production increase. Conversely, the low-price periods were always followed by a decrease in production.

The lag between the stimulus to mining, affected by a rise in price, and the actual increase in production, is largely due to the time required for producers to develop orebodies and erect plants.

Uses of Quicksilver

Quicksilver is one of the rarer metals, ranking second to gold in tonnage produced, and third to gold and silver in value per ton, but its importance is vastly greater than the quantity or the value of the output indicates.

Unlike gold and silver, quicksilver can not be used for coinage because of its liquid state, but principally because of this physical property it plays an increasingly indispensable role in the welfare of the nation.

Aside from general commercial uses, quicksilver is of paramount importance in time of war. This fact is recognized by the National Government which lists quicksilver, among 21 other commodities, as a strategic mineral, or in other words a necessary mineral of which there is a marked deficiency.[1]

Commercially, quicksilver (mercury) and its compounds have about 1000 distinct uses. The accompanying table gives the percentage of consumption rather than the number of flasks because year to year comparisons on this basis show but little change, as against actual figures concerning pounds or number of flasks.[2]

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[1] Merrill, Charles White, Strategic minerals in California: Cal. Jour. of Mines and Geol. Vol. 34, No. 3, p. 283, 1938.

[2] The United States standard weight of quicksilver per flask was 76.5 lbs. to June, 1904, and 75 pounds from that date until June, 1927. At the present time it is 76 lbs.

THE USES OF QUICKSILVER

Industries Using Quicksilver	Specific Use or Product	Form in which Quicksilver Is Used	Approximate per cent of total
Drugs and Chemicals	Pharmaceuticals	Mercurial Preparations; Organic Mercurials; Metallic Quicksilver	39%
	Dental Preparations	Redistilled Quicksilver	
	Chemical Preparations	Red and Yellow Mercuric Oxide; Calomel; Corrosive Sublimate	
	Seed Disinfectant	Metallic Quicksilver and Compounds	
Explosives	Detonators	Fulminate of Mercury	19%
Industrial and Control Instruments	Gas Pressure Gages; Flow Meters; Venturi Meters; Vacuum Pumps; Heat Control Devises; Automatic Motor Switches	Metallic Quicksilver	9%
Electrical Apparatus	Mercury Vapor Lamps; Rectifier Tubes; Certain Types of Batteries	Metallic Quicksilver	7%
Paint	Vermilion	Mercuric Sulphide	7%
Hats ("Fur Cutter's" Trade)	Felt	Mercuric Nitrate	5%
Chemical Industry	Caustic Soda	Metallic Quicksilver	3%
	Acetic Acid	Mercuric Salt as Catalyst	
General Laboratory Use	Industrial Laboratories; Science Laboratories in Schools and Universities	Metallic Quicksilver	2%
Gold Mining	Amalgamation	Metallic Quicksilver	1%
Miscellaneous Uses	Boiler Cleaning Chemicals	Quicksilver Amalgam	8%
	Manufacture of Fireworks	Sulphocyanate of Mercury	
	Marine Antifouling Paints	Red Oxide of Mercury	
	Wood Preservative	Mercuric Chloride	
	Grass Cultivation	Quicksilver Compound	
	Bearings for Lighthouse Lenses; Refining of Lubricating Oils; Supersensitizing Photographic Film; Mercury Boiler; Printing Processes	Metallic Quicksilver	

Economic Situation in 1939

The normal peacetime consumption of quicksilver in the United States during recent years has been from 25,000 to 35,000 flasks annually, about half of which has been imported. Our domestic output being inadequate, partly due to low average tenor of ore mined and insufficient price, the importation of quicksilver from foreign sources was necessary to meet the requirements. The salient figures for the few years preceding the recent outbreak of the European war in September, 1939, are as follows:

QUICKSILVER PRODUCTION—CONSUMPTION STATISTICS

1935-1938

(Flasks of 76 pounds)

	1935	*1936*	*1937*	*1938*
California production	*9,271	*8,693	*9,743	*12,277
Total U. S. production	17,518	16,569	16,508	17,991
Imports for consumption	7,815	18,088	18,917	2,362
Exports	?	263	454	713
Apparent new supply or total consumption	25,200	34,400	35,000	19,600
From all domestic mines—%	69	47	46	88
From California mines—%	37	25	28	63

Production figures from: U. S. B. M. Minerals Yearbook, 1939.
* These figures differ slightly from those compiled by Cal. State Div. of Mines.

The effects to the quicksilver mining industry that may result during the next year or two after 1939 from the obvious abnormal economic condition that goes with war is conjectural. Just prior to the World War, in 1914, operating costs and price received for quicksilver were nearly the same. Writing in 1918, Bradley * stated:

> "In 1914, the 'operating costs' of the larger companies amounted to about $35 per flask of quicksilver produced. This did not include interest, depreciation, amortization, etc. For the smaller operators the costs were relatively higher, and the market price having dropped to below $40 per flask ($37.50 average for July, 1914), but few properties were working."

During the early years of the war in 1915 and 1916, costs rose and so did the price received. The price was highest during the first two months of 1916, reaching a quotation of over $300 a flask during the third week in February, but the drop was rapid and the average price for the remaining war years was a little better than $100.

At the time of writing (October, 1939), a similar situation exists. Operating costs for the last few years have been about $55 to $65 per flask of quicksilver produced with the market price averaging about $75. The margin of profit is slightly larger with a relatively greater number of properties reporting production, but the total production has not been as great as for the corresponding period twenty-five odd years ago, although consumption has slightly increased.

The average New York market price per flask for 1938 was $75.47. By the end of August, 1939, just prior to war declaration, the price was about $90. During the month of September, after the outbreak of hostilities, the market price rose to as high as $170, and at the time of writing (October 4, 1939) the quotation for several days had been fairly steady at about $165. Buying was nominal and generally in small lots.

The situation at the end of 1939 is different from that existing in 1914, as Italy and Spain, the principal foreign producers, are not in the war and there is not likely to be a shortage under these circumstances. The present sharp rise in price is considered to a great extent due to forcing by consumers. The immediate result has been a stimulus to production of existing mines and decided interest towards development and operation of idle properties.

GEOLOGIC FEATURES OF THE CALIFORNIA QUICKSILVER DEPOSITS[1]

Historical Review

The geological study of the quicksilver deposits of California had its inception with the work of J. D. Whitney in 1865, who described many localities containing cinnabar, in conjunction with his work on the general geological survey of the State.[2] Becker followed in 1888, with an inclusive study of the quicksilver deposits of the Pacific Slope.[3] This

* Bradley, Walter W., Quicksilver resources of California: Cal. State Min. Bur. Bull. 78, 1918, p. 14.

[1] This section was published in "Mining World," Vol. 1, No. 5, 1939.

[2] Whitney, J. D., Geology of The Coast Ranges: Calif. Geol. Survey, Vol. 1, Pt. 1, 1865.

[3] Becker, George F., Geology of the quicksilver deposits of the Pacific Slope: Monograph U. S. G. S., 13, 1888.

work was done under the direction of the United States Geological Survey.

It was not until about 1903 that the State of California undertook to make a concentrated study of the then growing quicksilver mining industry within its boundaries. The results of this study for the State, made by Forstner,[1] were compiled in the form of a detailed description of the mines, and included general geological maps of the important quicksilver districts. This was a tremendous task, as it entailed an unlimited amount of original investigation. The arduousness of the task was accentuated by the fact that extensive areas had to be covered without present-day facilities for transportation, and with but few exceptions, the public land surveys showing the location of section corners were the only means by which the geological contacts could be plotted.

In reviewing the early literature on quicksilver deposits, the lack of correlation between the various observations of different authors is quite apparent. Nearly all are in agreement that quicksilver is found in rocks of various ages, usually as shallow, irregular deposits in the form of impregnations, in brecciated material and vein fillings, beds, and stockworks. It is also agreed that in nearly all cases observed, the deposits are associated with volcanic rocks and thermal activity. A correlation, based upon the general mode of occurrence of the ore, is not presented.

Schuette,[2] in 1930, was among the first to make a general correlation of quicksilver orebodies. His correlation is based on observed examples of structural traps which localized ore-shoots and concentrated the ore-minerals.

At the present date, the United States Geological Survey is making a geological study of certain of the important quicksilver districts in California. This work is incomplete, and no published results are obtainable.

Distribution and Age

The principal quicksilver ore deposits of California occur in the Coast Ranges within a northwest-southeast belt about 400 miles long; and extending from as far south as Santa Barbara, to Clear Lake on the north. The maximum width of this belt is about 75 miles.

Most of these deposits occur in the fracture planes of basic igneous rocks (especially serpentines) and their associated sediments (sandstones, shales, and cherts) which belong to the Jurassic Franciscan formation. Ores are also found in the Jurassic Knoxville formation and the overlying Cretaceous sandstones.

In addition to the principal Coast Range quicksilver belt, which represents a part of one of the most famous metallogenetic provinces of the world, there are other more scattered deposits in the State, as yet of relatively small economic importance. In two of these, the Cuddeback and Coso mines, the ore occurs in rhyolitic rocks.

Although the deposits may be found in rocks of various geologic ages, the time of deposition of the ore minerals appears to be a quite late epoch—late Pliocene, Pleistocene, and even Recent. In some

[1] Forstner, William, The Quicksilver resources of California: Calif. State Min. Bur. Bull. 27, 1903.

[2] Schuette, C. N., Occurrence of quicksilver orebodies: Trans. A. I. M. E., (1931).

localities, quicksilver minerals are even now being deposited by hot springs. This phenomenon is reported from the Sulphur Bank Mine, Lake County; The Geysers, Sonoma County; and Coso Hot Springs, Inyo County.

General Occurrence

Geologists classify quicksilver deposits as being *epithermal*, deposition taking place near the surface of the earth's crust under moderate pressure, and at a temperature of from 50°-200° C. (112°-392° F.).

This classification infers that quicksilver deposits are shallow, the orebodies not "going down" to any great depth. In general this is the case, and when the deeper quicksilver mines are compared with many of the gold and copper mines of the world, the superficial nature of quicksilver ore deposits is more fully realized. The New Almaden Mine, Santa Clara County, mined to a depth slightly in excess of 2400 feet, apparently reached the bottom of its ore zone, which for a period of years had been of low grade. On the other hand, many gold mines are being mined profitably at a depth in excess of 3000 feet and a few are as deep as 8000 to 9000 feet.

The form of quicksilver orebodies is characteristically irregular: as impregnations, as vein fillings, and as fissure and breccia fillings. It is not uncommon to find the deposits associated, directly or indirectly, with volcanic rocks, with evidence of active hot springs and fumeroles.

The many cases of direct hydrothermal activity, or evidence of such activity, that are in close relationship to quicksilver deposits, indicate that such solutions were undoubtedly the medium for carrying the minerals, possibly from a genetically related source magma.

Structural Control of Quicksilver Deposits

There are indications that many, if not all, of the quicksilver deposits of the Coast Ranges occur in fault zones, although not enough geological mapping has been done to give definite evidence except in a few instances. A general northwest-southeast alignment (N. 40° W.) of the districts and a local, more eastwardly and westwardly cross-alignment (N. 65°-75° W.) of the mining claims, as can be shown by careful plotting of all mines and claims on the State map, are indications of structural control. The fact that the Franciscan formation, including its intrusive igneous associate, serpentine, is always found to be the most fractured of all the rocks in the Coast Ranges, is probably the explanation of why the quicksilver deposits are most frequently found in it.

In other words, the association of quicksilver deposits with the Franciscan formation, and especially the serpentine, is probably structural, not genetic. The fracturing of the sedimentary rocks and the intricate crushing of the serpentine has afforded channel ways for the passage of ascending solutions to favorable zones of precipitation.

Not only is serpentine a hydrothermal alteration of peridotites and pyroxenites, but the occasionally associated, so-called "quicksilver rock," or "carbonate-silica rock," is an alteration of serpentine to a mass of opalized and surface oxidized material. In some quicksilver deposits, this material occurred in the surface outcroppings and was regarded as a favorable indication of the mineralized zone beneath it.

Although the deposition of minerals from solution may be attributed to factors such as pressure, temperature, and dilution, and the direction and general trend of solutions may be guided by structural control, a trapping of the mineral solutions is a necessary condition for primary concentration and the forming of a possible orebody. This appears obvious; but it remained for Schuette to emphasize the almost universal presence of an impervious capping that tended to localize the oreshoots of the major quicksilver orebodies of the world. He showed by a description of numerous well known mines that the richest orebodies, in every case, are those that have formed in the interstitial spaces of a porous, or brecciated, rock mass underlying relatively impervious material.

Geologic Features of the Principal California Districts

Sulphur Creek District

The Sulphur Creek district lies to the east of Clear Lake on the line between Lake and Colusa Counties, and comprises an area around Wilbur Springs on upper Sulphur Creek. The district has never been very productive, and the mines have been inoperative for many years.

The ores generally occur in serpentine or altered sedimentary rocks near the contact with the serpentine. Although hot mineral springs are very evident in the area, there is no indication of definite primary concentration—which may explain the absence of more than minor deposits in the district.

Knoxville District

The Knoxville district is mainly in the northern corner of Napa County, including adjacent areas in both Lake and Colusa Counties. Production has been generally sporadic from this district, with the exception of that from the Knoxville mine, the principal producer.

The orebodies in the district lie near a contact between serpentine and sandstones and shales, with a body of Tertiary basalt being closely associated with the Knoxville and Manhattan mines. Schuette [1] believes that this basalt originally extended over a wide area, and formed the requisite trap conditions for the formation of the orebodies. Subsequent erosion has removed all but traces of this extrusion and also, no doubt, a considerable portion of the original orebodies.

In the vicinity of Knoxville, as in the Sulphur Creek area, there are numerous mineral springs that are probably of solfataric origin.

Clear Lake District

The Clear Lake district includes the general area around the southern half of Clear Lake, and is entirely within Lake County. The only production of any importance from the district has been from the famous Sulphur Bank mine, which is operating at the present time.

This region has in the past been the scene of intense volcanic activity, a large part of it having been covered by flows of lava. The history of the deposits, as typified by the Sulphur Bank mine, is similar to that at the Knoxville; but at the Sulphur Bank the process of ore deposition is in action at the present time.

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[1] Schuette, C. N., op. cit., p. 424.

The mineralizing solutions rose along fault fissures, and became trapped by a Quaternary basalt capping, depositing cinnabar both in the cracks of the basalt and the brecciated rocks directly below. Active solfatara and thermal springs are still depositing sulphur and cinnabar. Calcium carbonate, in the form of banded aragonite, has also formed on old mine timbers during the past 50 years.

Mayacmas District

The Mayacmas district is so named from the Mayacmas Range of mountains, of which Mount St. Helena and Cobb Mountain are the most prominent points. The numerous mines in the district are scattered along a general line from near Cloverdale in the northwest to Pope Valley in the southeast, in Sonoma, Lake and Napa counties. It is interesting, in the light of Schuette's concept of impervious cap-rock, to note a part of Forstner's general description of the district:[1]

> "The general trend of the belt is northwest. In its southeastern part, in Napa County, it is in very close proximity to a region of very intense and probably prolonged eruptive action, covering Tertiary and post-Tertiary periods. The center of eruptions in this region was probably in the territory bounded by Mount St. Helena, the Twin Peaks (or Sugar Loaves), and High Peak; the flows have, however, spread over a large adjoining territory. Outside of this are found a great many other eruptive bodies in this district, of which the more prominent are: The basalt body on Oathill, some smaller ones in the territory of the Aetna Consolidated Company, and andesitic eruptive body northeast of Oathill, Pine Mountain, Cobb Mountain, and others. This district is hence a region of intense eruptive action. Large masses of lava have covered parts of it, and while partly eroded, extensive sheets of tuff cover at present parts of it to a greater or less depth, and make it very difficult to determine the limits of the cores of igneous rocks. The present deeply carved topography of the region is largely governed by the erosion of this capping."

For the most part, the quicksilver deposits in the Mayacmas district occur on or near the contact of Franciscan sandstone and chert, and serpentine. The Oathill orebodies occur in the sandstone some distance north of the serpentine contact, the solutions probably being trapped by the original basalt capping. Schuette thinks that much larger orebodies than those mined were probably lost by erosion and deposited as placers in the valleys below. The most westerly deposit in the district is located at the Cloverdale mine. The orebodies lie under a heavy attrition gouge on a sandstone chert contact. The solutions evidently came up along diorite (?) dikes and were deposited in the chert-breccia beneath the heavy layer of gouge which acted as the trap.

The Mayacmas district is also interesting because it is a locality for the occurrence of "quicksilver rock," often mentioned in the earlier writings on California quicksilver mines. This opalized rock is best seen at the Great Western mine. The term "quicksilver rock" was probably so named by its prominence over surrounding rocks and the fact that the first discovered occurrence contained cinnabar. This initially observed association resulted in persistent prospecting at many other localities of opalized rock occurring in California. The efforts were mainly wasted, and it is apparent that the term is misleading.

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[1] Forstner, William, Quicksilver resources of California; Calif. State Min. Bur. Bull. 27, p. 35, 1903.

There are many active hot springs along the general line of the Mayacmas district, and in some cases they are being utilized for curative purposes. ''The Geysers'' and Aetna Springs are examples. The Geysers are misnamed, being true fumeroles rather than intermittently spouting boiling springs. The intensity of pressure in the thermal area has been realized through harnessed wells, with a portion of this potential power being used at the present time. There has been a considerable deposition of sulphur at this locality, and though no cinnabar has been found, a small amount of native quicksilver has been recovered from steam pipes connected to the wells.

New Almaden District

The New Almaden district is about 12 miles south-southeast of San Jose; the mines are on a ridge back of the foothill spurs which form the western boundary of the Santa Clara Valley at a point near Coyote. None of the mines are producing at the present time, but they are interesting from the standpoint of past importance. Headed by the New Almaden, the total production from the district is far above that of any other quicksilver mining area in the United States.

The orebodies of the district occurred in an attrition zone at the contact of serpentine which had been intruded into Franciscan sandstones and shales. Layers of gouge, or ''alta,'' forming the hangingwall of the ore, were the perfect traps necessary for the deposition of these rich orebodies.

New Idria District

The New Idria district lies chiefly in the southeast corner of San Benito County, but includes a portion of Fresno County. There are two other lesser districts, the Stayton and the Central San Benito which are comparatively unimportant.

Like the New Almaden, the orebodies of the New Idria district, for the most part, lie near the contact between the serpentine and Franciscan sandstones and shales, the ore being trapped by hangingwall gouge. The most typical as well as the most important mine in the district is the New Idria.

San Luis Obispo County Districts

The Oceanic, Adelaida, and Pine Mountain districts, and what is referred to as the San Carpojaro district, are all adjacent and are situated in the northwestern corner of San Luis Obispo County, in the Santa Lucia Range.

The deposits in the districts are mainly in contorted rocks of the Franciscan series, the ore having been concentrated under gouge hangingwalls in localized zones. The Oceanic mine, in the district of the same name, is the one exception to the general occurrence, and is the chief producer in the region. The geology of this mine has never been satisfactorily worked out; but it is very evident that the ore solutions were concentrated in their present position by the so-called mud-rock hangingwall. The orebodies are found in porous Miocene sandstone, and to a minor extent, in the mud-rock. The influence of the relative porosities of the two rocks on the grade of the ore as deposited is well illustrated. The sandstone ore is of consistently higher grade than that of the relatively impervious mud-rock.

The Rinconada mine, although not included in the aforementioned districts in the county, is of interest. This deposit is located about eight miles east of San Luis Obispo, and is of comparatively low grade. There is no indication of any possible cap-rock in the area that could have resulted in a primary concentration of the mineralizing solutions which, therefore, spread out in minor quantities through the surrounding rock.

Santa Barbara County Districts

In the southern part of Santa Barbara County are two districts that are commercially of minor importance, and about which the geological accounts are meager.

The Cachuma district is situated about 20 miles northwest of Santa Barbara, and the Los Prietos district is in the Santa Ynez Mountains, about eight miles north of Santa Barbara.

Quicksilver Mineralization

The most important ore-mineral of quicksilver is *cinnabar,* the brilliant red sulphide of mercury,* from which 95% of the world's output of the liquid metal is obtained. Although there are about 25 known mineral species that contain mercury as part of their chemical composition, only two others, besides cinnabar (with a few rare exceptions) occur in commercial quantities: *native mercury,* which is fairly common; *metacinnabar,* the black sulphide, which is the least common of these three ore-minerals.

All these minerals are commonly associated with marcasite (less frequently with pyrite). They may occur as disseminated specks scattered through sandstone or some other porous rock, or as irregular bunches and streaks in altered rocks of various kinds.

Cinnabar is generally massive, earthy, or minutely crystalline, but good crystals are occasionally found. It is distinguished from other red-colored minerals by its high specific gravity, brilliant adamantine luster, and perfect cleavage. Associated with calcite, barite, quartz, chalcedony, and opal, as gangue minerals, cinnabar may be found in definite, though usually irregular veins.

Cinnabar is deposited from hot alkaline solutions, while metacinnabar is released from acid solutions. The principal primary ore-mineral is cinnabar, while metacinnabar may be formed by acid solutions acting upon cinnabar. The source of the metal is considered by many geologists to be from deep-seated rock magma, but the existence and position of such a magma is only a conjecture.

Tenor of the Ores of Quicksilver

The tenor of the quicksilver ores of the world varies over a wide range, as little as 0.15 per cent quicksilver per ton to as high as 5-10 per cent. In California, profitable returns have been won from direct furnace reduction of ore averaging from 5-10 pounds (0.25%-0.50%) of quicksilver per ton. By the process of concentration, ore with an average grade as low as three pounds (0.15%) has been economically mined and treated at a profit.

* Although *quicksilver* is the generally accepted term used by the industry, the name *mercury* (the metallic element Hg) is always used in more technical descriptions, as in reference to the chemical composition of cinnabar, *i.e., mercuric sulphide,* HgS.

MINES AND PLANTS, ALPHABETICALLY BY COUNTIES

ALAMEDA COUNTY

(See under OTHER COUNTIES AND MINES, page 476.)

ALPINE COUNTY

MOGUL PEAK CLAIM

Location. M. D. M.,[1] T. 10 N., R. 21 E., in or near Sec. 30, in the Mogul Mining District a few miles north of the town of Loope.

Ownership. Wesley Crothers and Dick Brune, Markleeville.

This occurrence of cinnabar has only recently been discovered and is the only reported quicksilver mineralization in Alpine County. In 1938, high-grade float was discovered in Mogul Canyon, but no material was found in place until the spring of 1939, at the present location. Cinnabar occurs as finely disseminated grains in oxydized siliceous veins in andesite. The veins or series of veinlets are from 2 to 8 in. wide and have a nearly vertical dip. The development work to date consists of 2 adits, 45 ft. and 65 ft. and a shaft about 20 ft. deep. The ore uncovered has been low-grade. No quicksilver has been produced as yet, but it is reported that the owners are installing a retort.

CALAVERAS COUNTY

(See under OTHER COUNTIES AND MINES, page 476.)

COLUSA COUNTY

Mining activity for quicksilver in Colusa County has never been extensive, and of late years it has been practically at a standstill. The county is credited with a total yield of approximately 4900 flasks to the end of 1938.

The mines of this county are located within area of eight square miles, comprising part of the Sulphur Creek District which lies in the western portion of the county and extends westward into Lake County. The principal producer has been the Manzanita mine with a total production of 2468 flasks.

CENTRAL EMPIRE GROUP

Location, M. D. M., T. 14 N., R. 5 W., Secs. 28 and 29, adjoining Wilbur Springs resort on the east, with the mining property located on both sides of Sulphur Creek.

Ownership. J. W. Cuthbert, Wilbur Springs, California.

Production History. 1873, 1875, 1890, 1926.

The old Empire mine of this group is located in section 29 on the south side of Sulphur Creek, and was known as a producer in the seventies, and again in 1890. The mining property was then deserted and remained idle until 1926. The central claims were opened up

[1] Mount Diablo Meridian.

by lessees in 1926, and a small rotary furnace was installed. The furnace did not prove successful, and all the ore mined was treated in pipe retorts. After a single year of activity, the mine was shut down and has remained idle to date.

General Geology. Ore was deposited in a brecciated and silicified serpentine near a serpentine-shale contact. Cinnabar occurs in seams which strike in all directions through the serpentine. Development to date has disclosed an ore zone about 30 ft. in width, which extends to a depth of about 50 ft.

Bibliography: State Mineralogist Reports XI, p. 186; XII, p. 359; XIII, p. 594; XIV, p. 189. Bulletins 27, p. 43; 78, p. 38.

ELGIN MINE

Location. M. D. M., T. 14 N., R. 6 W., Sec. 13; and T. 14 N., R. 5 W., Sec. 18, about 4 miles northeast of Wilbur Springs resort.

Production History. The Elgin mine was first noted as early as 1875; and some development work, resulting in a small production, was reported during 1892-1893. Another small yield was made in 1905 and again in 1916. The mine was purchased by the New Elgin Quicksilver Mining Company in 1917, and some development was done although no ore was treated. An attempt was made to recover sulphur from the ore in 1918; but the close of the World War terminated all activity at the mine. The mine was closed down the following year, and it has remained idle since.

General Geology. The region surrounding the Elgin mine is composed of serpentine and shale which have been greatly altered by thermal waters carrying such elements as sulphur, calcium, and magnesium. The ore-bearing zone is a ledge of opalized rock carrying cinnabar closely associated with sulphur, calcium carbonate, and magnesium carbonate. The sulphur is so abundant that many of the early operations consisted of attempts to recover this mineral.

Bibliography: State Mineralogist Reports XI, p. 182; XII, p. 359; XIII, p. 594; XIV, p. 189; XXV, p. 296. Bulletin 27, p. 43; 78, p. 36.

MANZANITA MINE

Location. M. D. M., T. 14 N., R. 5 W., Sec. 29, one mile west of Wilbur Springs resort.

Ownership. Western Mergers Mine Company. George Newhall, president.

Production History. 1902-1909, 1911, 1917, 1929-1934.

The Manzanita mine was first noted in 1863, and was operated for many years for the gold in the ore. Cinnabar was recovered and concentrated along with the gold recovery; but segregated figures on the production of quicksilver are not available prior to 1900.

In 1902, recorded operations for the recovery of cinnabar started, and were continuous to 1909. A small production was reported in 1911, aftar which time the mine was closed down. The Cerise Gold Mining Company commenced operating the property in 1917, and reported a small production for that year only. The Cherry Hill Gold Mining Company purchased the mine in 1922, but did not pro-

duce any quicksilver for the next seven years. In 1929, the mine was under the control of H. M. Newhall and Company, and various operators have leased the property since that time, including the Shanjay Quicksilver Mining Company during 1930 and 1931, the Western Mergers Company in 1932-1933, and S. W. Taylor and T. A. Duncan in 1934. The mine has been idle for the past three years.

General Geology. The Manzanita property is located in an area of thinly bedded, altered shales, sandstones, and conglomerates. Near the border of the property to the north, is a belt of serpentine; but this rock apparently is not closely related to the mineralized zone, except as a possible source of mineral solutions.

Fracturing, faulting, and contortion of the sedimentary series is quite evident in the vicinity of ore deposition. An ore-bearing ledge of chalcedonic rock carrying cinnabar and gold strikes through the sediments with a very irregular trend. The shales and sandstones on both sides of the ledge have been partially impregnated with cinnabar.

Mine and Plant. Mining has been done on this property by glory-hole methods and by underground workings, most of which are now caved and abandoned. The treatment problem has been one of separating gold from cinnabar. This was done for many years by gravity concentration methods, with the cinnabar concentrates being treated in retorts. Because these concentrates were recovered in comparatively small amounts, there has been no need for the installation of a mechanical furnace.

Bibliography: State Mineralogist Reports VIII, p. 157; XI, p. 185; XII, p. 359; XIII, p. 594; XIV, p. 189; XXV, p. 298. Bulletins 27, p. 44; 78, p. 38.

RATHBURN GROUP

Location. M. D. M., T. 14 N., R. 5 W., on or near Sec. 6. This group of five claims, including the May Day, Last Resort, Old Kentucky, and Juniper, was located on Dead Shot Ridge which forms the west side of Bear Valley about 4 miles north of Wilbur Springs.

Ownership. Last reported owner was J. P. Rathburn, Williams, California. As the mine was reported abandoned in 1915, the present ownership is unknown.

Production History. Pre-1892, 1893-1894.

It is reported that prior to 1892, this group of claims had been worked at intervals for several years, the ore being reduced in small retorts. Part of the small production of 150-odd flasks for 1893-1894 was from the old nearby Farris Claim.

General Geology. The ore in the form of cinnabar occurred on the fracture surfaces of a siliceous vein material in serpentine.

Bibliography: State Mineralogist Reports XI, p. 181; XII, p. 359; XIII, p. 594; XIV, p. 190.

WIDE AWAKE MINE (Formerly Buckeye Mine)

Location. M. D. M., T. 14 N., R. 5 W., Sec. 29, about one mile southeast of Wilbur Springs resort.

Ownership. A. A. Gibson, Wilbur Springs, California.

Production History. 1875-?, 1896-1900, 1932, 1937.

The Wide Awake mine was first operated in 1875, under the name of Buckeye Mine. Work was only sporadic for a number of years, and in 1896 a shaft was sunk on the property. Production ceased in 1900, and the mine was abandoned. The only recent work done on the property was the recovery of a very few flasks of metal in 1932, and again in 1937, by the present owner, A. A. Gibson.

General Geology. The ore found at this mine occurs at the contact of serpentine and shale. Here cinnabar has been deposited in a zone about 5 feet wide, which is traceable in a northwest direction for about a mile. The footwall is serpentine, and the hangingwall is shale.

Bibliography: State Mineralogist Report I, p. 27; XI, p. 187; XIII, p. 594; XIV, p. 190; XXV, p. 299. Bulletins 27, p. 45; 78, p. 39.

WILBUR HILL MINE

Location. M. D. M., T. 14 N., R. 5 W., Sec. 28, on Sulphur Creek, between Wilbur Springs and the Manzanita mine.

Ownership. Last reported, Wilbur Springs Company, Wilbur Springs post-office.

Production History. A small amount of quicksilver was produced in 1916, with a concentrator and retort. Some development work was done subsequently, but the mine has been idle since 1918.

CONTRA COSTA COUNTY

The only deposit of quicksilver of commercial value, in Contra Costa County, lies on the eastern slope of Mt. Diablo, and is located within the property of the Mt. Diablo quicksilver mine.

MOUNT DIABLO MINE (Formerly Ryne)

Location. M. D. M., T. 1 N., R. 1 E., Sec. 29, on the eastern slope of Mt. Diablo, about 10 miles southeast of Concord and 4 miles east of Clayton.

Ownership. Owner: Mount Diablo Quicksilver Co., Ltd.; Lessee and operator: Bradley Mining Company, Crocker Building, San Francisco, California. Worthen Bradley, president.

Production History. 1875-1877, 1930, 1932, 1936-—.

The deposit of quicksilver on Mount Diablo has been known since 1875, but, following a short period of operations, it remained undeveloped for many years. Renewed interest in quicksilver in recent years led to the reopening of the mine by the Mount Diablo Quicksilver Mining Company in 1930. A small production was recorded that year, and again in 1932. Beginning in 1936, the present operators began extensive development and production rose gradually to sizeable proportions during 1938 and 1939.

General Geology. The Mount Diablo mine is located in an area of serpentine and Franciscan strata typical of many of the quicksilver belts of the State. Ore deposition has taken place in a zone of opalized porous rock, commonly called "quicksilver rock." Cinnabar and metacinnabar have been deposited within this rock in about equal quantities, with the metacinnabar occurring in rather massive form closely

associated with pyrite and marcasite. There is no indication of mineralization having taken place beyond the zone of opalized porous rock.

Mine and Plant. Access to the mine is afforded by an adit and a joining winze sunk to a depth of 165 ft. Development consists of two levels below the adit; one at a depth of 80 ft., and the other at a depth of 165 feet. Mining is also being carried on by open pit and gloryhole method above the underground workings.

There are two rotary furnaces in the plant, only one of which is now operating. To the south of the furnace building a new D retort and small condensing unit have recently been installed. During operating periods, a 19-gravity [1] fuel oil, costing 3.5 cents per gallon, is used for firing purposes.

Bibliography: State Mineralogist Report VIII, p. 162. Bulletin 78, p. 41.

DEL NORTE COUNTY

Quicksilver deposits in Del Norte County have been known since the early fifties, when the first placer miners in the region mined cinnabar and produced quicksilver for use in amalgamation. There are only two known deposits of any commercial value, and the production from these has been small.

BIG BOY CINNABAR GROUP

Location. H. M.[2], T. 19 N., R. 2 E., Sec. 36, on the California-Oregon State line, about 4 miles northeast of the Sunny Brook mine, and about 10 miles air line west of Monumental.

Ownership. O. H. Hagberg, N. W. Lipple, George Davis, partners (1933).

Production History. The original location was made by John Griffen sometime after the World War. Griffen attempted to concentrate the ore in a rough sluice box, using two 4-in. pipe retorts to treat his concentrate. The arrangement was not successful, and at a later date the J. I. L. Dredging Company of Spokane leased the property. Concentration by sluicing was again tried, and again proved very inefficient. Since 1933, there has been no recorded activity on the property.

General Geology. The mineralized area at the Big Boy mine is a large low grade deposit of cinnabar, containing an estimated 25,000,000 cu. yd. of 3- to 5-lb. ore. Cinnabar has been deposited as small fissure fillings in a large mass of altered diorite.

Bibliography: State Mineralogist Report, XXIX, pp. 157-158.

SUNNY BROOK MINE (Formerly Diamond Creek)

Location. H. M.,[2] T. 8 N., R. 2 E., NW¼ Sec. 11, about 18 miles by road west of Monumental and 4 miles southeast of the Big Boy Group.

Ownership. Last reported (1933), Lee Brown and John Taggart, Monumental.

Production History. 1850-1860, 1917.

The original discovery of cinnabar in the county was made on the location in 1850, as noted in the county discussion. In 1916, the prop-

[1] The term gravity refers to the standard of specific gravity applied to petroleum and its products, adopted by the American Petroleum Institute (A. P. I.).

[2] Humboldt Meridian.

erty was relocated by the Diamond Creek Cinnabar Company. One flask of quicksilver was produced in 1917 with a 3-pipe Johnson-McKay retort. There has been no recorded production since that date. The present owners did some development in 1933, but did not reduce any ore.

General Geology. The country rock of this deposit is serpentine. Veins of quartz in the serpentine carry cinnabar in small stringers, and in places cinnabar is found in fissures within the serpentine itself.

Bibliography: State Mineralogist Report XXIX, p. 293. Bulletins 27, p. 195; 78, p. 41.

EL DORADO COUNTY

BERNARD CINNABAR MINE (Originally called the Amador)

Location. M. D. M., T. 8 N., R. 10 E., Sec. 4, on Fanny Creek, 2 miles west of Nashville, and about 8 miles from Shingle Springs.

Ownership. Last reported, Bernard Cinnabar Mining Company, San Francisco, California.

Production History. 1860's.

The mine was first opened up in the '60's, and some quicksilver produced; then reopened in 1903 when only development work was done. It has been idle since.

General Geology. The deposit is a bedded vein in slates and quartzitic rocks; and the cinnabar, accompanied by pyrite, occupies interstitial spaces. Serpentine occurs about one-quarter of a mile to the west.

Bibliography: State Mineralogist Reports XII, p. 359; XV, p. 306; Chapter rep. bien. period, 1915-1916, p. 36; Bulletin 27, p. 190; Bull. 78, p. 42, U. S. G. S. Mon. XIII, p. 384. Placerville Folio (No. 3), p. 3. Geol. Surv. of Cal., Auriferous Gravels, p. 367. Min. & Sci. Press, vol. 31, 1875, p. 718.

FRESNO COUNTY

Prior to 1888, the New Idria district was located within the boundaries of Fresno County, and in early reports the production from these mines was credited to Fresno County. The boundary line was changed in 1889, so that there are only three mines of any commercial importance left in the county. Two of these, the Archer and Del Mexico, are east of the New Idria mine; and the third, the Mercy mine, is located north of the New Idria, on Little Panoche Creek.

The total production, to the end of 1938, is 1551 flasks, the majority of which has come from the Mercy mine.

ARCHER MINE

Location. M. D. M., T. 18 S., R. 13 E., Secs. 2 and 3, 28 miles northwest of Coalinga, near the Mexican mine and due east of the New Idria mine.

Ownership. Joseph Byles and Sons, Coalinga, California.

Production History. 1916-1918, 1928-1930, 1932- —.

Although a small amount of quicksilver was retorted prior to the World War, there is no recorded production at the mine until 1916. It was operated through 1917 and 1918 by Joseph Byles and Sons, who

have owned the property continuously to the present date. The property remained idle until 1928, with a small production recorded for that year by Mr. Byles. In 1929, a small production was recorded; and in 1930 the property reached the peak of production, with Byles operating part of the year and leasing to H. Carhartt for the remainder of the year. During 1931, there was no recorded production; but from 1932 to 1938, a few flasks were recovered each year by Byles and Sons.

General Geology. The ore mined is cinnabar, associated with pyrite, in a country rock of serpentine and slate.

Bibliography: State Mineralogist Report XIV, p. 462; XXV, p. 329. Bulletin 78, p. 43.

DEL MEXICO MINE (Formerly Mexican)

Location. M. D. M., T. 18 S., R. 13 E., NE¼ Sec. 22, about 9 miles southeast of Idria near the Archer mine.

Ownership. Operated by C. Perez, Mendota, California.

Production History. 1860- —, 1935-1936.

This old property was originally located in the sixties, and produced some metal, although the records are not clear for this early period. No further production is recorded until 1935. During that and the following year, several flasks were recovered by retorting.

General Geology. The ore is found close to the contact of the Franciscan formation and the overlying Panoche sandstone. Cinnabar, associated with siliceous material and iron oxide, is generally found in the Franciscan sandstone.

Bibliography: State Mineralogist Report, XIV, p. 462; XXV, p. 331. Bulletins 27, p. 119; 78, p. 43.

MERCY MINE (Formerly Mercey, also Pacific)

Location. M. D. M., T. 13 S., R. 10 E., Secs. 32 and 33; T. 14 S., R. 10 E., Sec. 5, about 25 miles southwest of South Dos Palos, on Little Panoche Creek.

Ownership. W. M. Biaggi, San Jose, California.

Production History. 1860- —, 1911-1914, 1918, 1929-1934, 1938- —.

This group of claims comprises the old patented claims of Arambide and Aurecoechea, described by Forstner in 1903. The first work done here was in the sixties, by Mexicans, and a fairly high production is reported to have come from them. But by the time Forstner made his report in 1903, the claims were practically abandoned. In 1911, the Pacific Quicksilver Company took over, and enlarged the property to include 18 claims and five millsites. This company operated for three years, and then closed down in 1914, after having produced only a small amount of metal. The property remained idle until 1917. At that time it was bought by the New Mercy Mining and Milling Company. The furnace, a 24-ton Scott, was fired up for only ten days in 1918, but only a few flasks were recovered. The property was then split up with the old Arambide, Aurecoechea, and Mercy claims making up the Mercy mine, and the rest of the property going to other interests which now comprise the Hollister group. L. B. Chenwith did some surface work in ensuing years, locating and relocating claims, and tracing out mineralized zones. In 1929, the Mercy mine and all equipment were sold, under foreclosure of a deed of trust, to W. M. Biaggi of San

Jose. Mr. Biaggi operated the property in 1929 and 1930, producing a little quicksilver. He then leased the property to Benjamin C. Warnick in 1931; and to W. G. Imel in 1932, 1933, and 1934. No record of production is available for the period since that date except for a few flasks produced by concentration and retorting in an experimental way by O. R. Rogers in 1938, and by John Barness in 1939.

General Geology. The country rock of the area is a metamorphic sandstone which is cut by various quartz veins. The cinnabar ore occurs in zones of leached ocherous sandstone, associated with the quartz in the veins. The cinnabar is not easily seen by the eye, and its presence must be determined largely by panning.

Bibliography: State Mineralogist Report XIV, p. 464; XXV, p. 330; Bulletin 27, p. 119; Bull. 78, pp. 44-46. U. S. G. S. Mon. XIII, p. 380.

GLENN COUNTY

(See under Other Counties and Mines, page 476.)

HUMBOLDT COUNTY

(See under Other Counties and Mines, page 476.)

INYO COUNTY

Mining operations in this county have been in progress only during the past few years. The single deposit of commercial value lies at Coso Springs, in the Coso Mountains of southwestern Inyo County.

COSO MINE

Location. M. D. M., T. 22 S., R. 39 E., Secs. 5, 6, 7, 8, about half a mile west of Coso Hot Springs, and about 11 miles by desert road east from Coso Junction on U. S. Highway No. 395.

Ownership. F. J. Sanders, Santa Barbara, California; under lease and bond to A. W. Leege, Santa Barbara, California.

Production History. 1935-1936, 1938- —.

The presence of cinnabar in the area surrounding Coso Hot Springs had been known for many years before any attempt was made to exploit the deposits. In 1930, J. T. Sanders and Carl W. Rodecker, of Little Lake, received a mineral patent on the land, and started to develop a large area. Numerous trenches and test pits were excavated in all sections of the deposit and by 1935, it was apparent that the mineral existed in commercial quantities. Sanders produced a few flasks in 1935 and 1936, by treating a small amount of ore in a retort. At the beginning of 1937, the present owner gained full control of the property, started additional development, and installed a Herreshoff furnace.

General Geology. The area in which the Coso mine property and the Coso Springs resort lie is one of intense thermal activity. Boiling hot springs and steaming vents are common throughout the region, with the greatest evidence of thermal activity showing in Devil's Kitchen, now the center of mining operations.

Interbedded layers of rhyolitic ash and tuff, and flows of rhyolite, form the rocks of this region. Thermal action has decomposed the

rocks to a great extent, and there is widespread silicification by mineral waters. In the vicinity of active fumeroles, crumbly deposits of siliceous sinter have been formed. The general plane of weakness, along which the mineral solutions rose, strikes across the property in a northeast-southwest direction. Wholesale impregnation of the overlying rocks by solutions is indicated by the extensive areas in which cinnabar is found. However, the commercial deposits are apparently limited to the Devil's Kitchen area, and to an area just northeast of Devil's Kitchen known as the Nicol property.

Cinnabar and metacinnabar occur as paint and crusts closely associated with crystalline sulphur throughout the siliceous sinter and other rocks. Mercury minerals are being deposited at the present time, as shown by experiments made on the vapors emitting from some

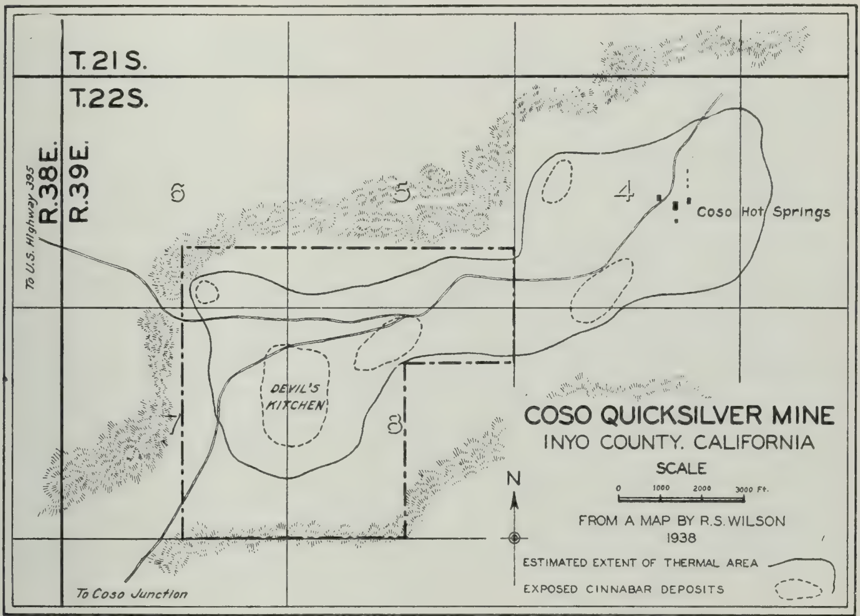

FIG. 1. Plan of the Coso Quicksilver Mine, Inyo County, showing the extent of the thermal area and exposed cinnabar deposits.

of the steam vents. It is reported that copper plates placed over these vents become coated with quicksilver within a short time.

The true grade of the deposits has not yet been determined; but the management believes that the ore in Devil's Kitchen will prove to run over 8 lb. per ton.

Mine and Plant. Mining operations are centered mainly in Devil's Kitchen. Here are three zones of thermal activity, locally known as "craters," situated in a north-south line at different elevations. The lowest, or north crater does not carry cinnabar in commercial amounts. Mining is active, however, in the intermediate crater; here a small power shovel loads the soft, crumbly ore into a truck which transports it to the plant about a quarter of a mile away.

The plant is a complete Herreshoff installation, including a 20-ton, 5-hearth butane gas fired furnace, Cottrell dust precipitator, and a

condensing unit with 8-in. diameter vertical pipes. The fine-ore bin is offset from the drying hearth of the furnace by about 12 ft. This differs from the common practice of placing the ore bin directly over the drying hearth, and entails a more complicated feeding arrangement.

The property is at present working seven to nine men, exclusive of management.

Bibliography: State Mineralogist Reports XXVI, p. 59; XXXIV, p. 460.

KERN COUNTY

Kern County can not be classed as one of the main quicksilver producing counties of the State. All of the production of the county has come from a single property, the Cuddeback Cinnabar mine.

Production commenced here in 1917, and has been carried on intermittently to the present time. The total production, to the close of 1938, amounts to 1264 flasks.

CUDDEBACK MINE

Location. M. D. M., T. 31 S., R. 32 E., Sec. 27, on patented agricultural land half a mile north of the main Tehachapi Pass highway in the Sierra Nevada Range, and 3 miles from Keene Post Office. It is accessible by a dirt road which branches off from the main highway just above the famous Tehachapi loop of the Southern Pacific Railroad.

Ownership. Cuddeback Cinnabar Corporation, Tehachapi, California. C. D. Cuddeback, president.

Leased by the Walabu Mining Company. A. E. Wallace and Walter Buaas, partners.

Production History. 1916-1920, 1929-1931, 1936- —.

In April of 1916, J. E. Hicks of Tehachapi made the discovery of cinnabar on this property. He and W. N. Cuddeback commenced operations with a 12-pipe Johnson-McKay retort. In 1917, the Cuddeback Cinnabar Company, headed by A. J. Blackley, took a lease on the property and operated for about a year. The mine remained idle from 1918 to 1927, at which time it was taken over under lease from the present owners, by the Santa Ana Mining Company, headed by C. D. Holmes. This company held an option on the property until 1931. Holmes installed the present furnace, and did considerable development work, and recorded some production. After Holmes gave up his option, the property remained idle until 1936, at which time it was leased by the Walabu Company which operated to February, 1938. At that time the mine was shut down due to a decreasing grade of ore plus a low price for quicksilver. During 1939 the mine again started operating.

General Geology. The deposit is unique in California, as it is located outside the generally recognized quicksilver belt of the State, and is the only known place in the Sierra Nevada where cinnabar occurs in commercial quantity.

The country rock of the region is of a granitic type, undoubtedly associated with the Sierra Nevada batholith. In the area surrounding the mineralized zone, a series of light colored, more or less altered, rhyolite dikes cut across the granitic formation. The largest dike has an approximate east-west strike and dips about 45° north. It

is about 150 ft. wide at the mine, and is composed of fractured and platy rhyolite containing quartz and feldspar phenocrysts, the feldspar having been altered almost beyond recognition. The rhyolite is quite porous and carries considerable cinnabar in small, disseminated specks which are not readily discernible. Most of the mineral has been deposited in fracture fillings, occasionally as wide as three or four inches, but generally not more than a fraction of an inch or so in width. A study of several thin-sections of rhyolite from the ore zone revealed that the cinnabar occurs as impregnations in the rhyolite, with no indications of replacement having taken place.

Mine and Plant. Mining at this property is done by glory-hole methods and by small open stoping methods. The mine is developed by numerous short tunnels, drifts, and cross-cuts. The largest known

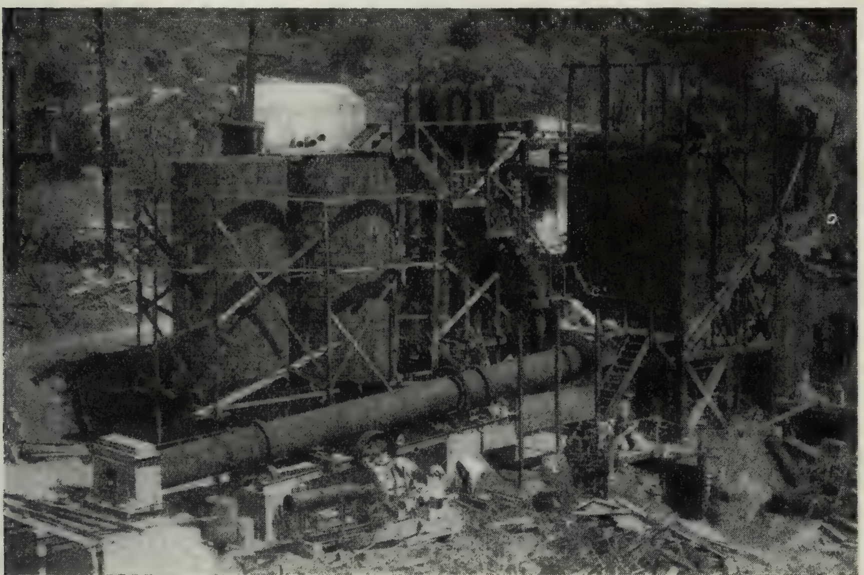

FIG. 2. Rotary furnace and condensing system, Cuddeback Mine, Kern County. The plant has since been completed and a protective structure built around it. An oil preheating unit is coiled around the furnace at the left or firing end; a Sirocco dust collector is between the blower and the condenser pipes at the right or header end of the furnace. *Photo by P. L. Blodgett.*

orebody is now inaccessible, as it lies underneath the east drift, and was formerly entered through no. 2 shaft. This shaft was sunk in the stream bed, and soon filled with water. It now lies caved and abandoned.

Reduction equipment consists of an 8 in. by 10 in. Blake jaw crusher, a 3 ft. by 48 ft. rotary furnace of 40 tons capacity, twelve 16-in. diameter cast iron condensing pipes, and 2 redwood settling tanks. The present operators had some difficulty with the furnace when they first opened up the mine, as leakage occurred at the dust chamber. However, improvements were made, and the recovery is reported to have been quite good at the time of shut-down in 1938.

During present operations (1939) the rotary furnace is being fired by butane gas which has been found to be a satisfactory fuel.

The average cost of mining, not counting administrative costs, ran slightly under \$3.00 per ton during 1937-38. The ore was reported to run about 3 lb. per ton, which would explain the reason for the 1938 shut down, with the price of quicksilver averaging a little under \$75 per flask (February 1938).

Bibliography: State Mineralogist Reports XVII, p. 314; XXV, p. 60. Bulletin 78, p. 47. Min. Sci. Press, Vol. 114, p. 79.

FICKERT-DURNAL MINE

Location. M. D. M., T. 31 S., R. 32 E., Sec. 26, about 1½ miles east of the Cuddeback mine, on the Cuddeback ranch property.

Ownership. C. D. Cuddeback, Tehachapi, California.

Production History. 1917.

In 1917, the property was leased by Phillip Fickert and J. A. Durnal, who set up a Johnson-McKay retort. Some superficial mining was done, but only a small amount of quicksilver was recovered. The lease was finally given up, and the equipment was sold to Cuddeback. He found the condensing pipes filled with synthetic cinnabar, and surmised that the lessees had failed to use any lime in their treatment process. No work has been done on the property since 1917.

General Geology. The geology is similar to that of the Cuddeback mine, with mineralization having taken place in a rhyolite dike intruded into the granitic country rock.

Bibliography: State Mineralogist Report XVII, p. 314. Bulletin 78, p. 49.

TARDY CLAIMS

(See under Other Counties and Mines, page 476.)

KINGS COUNTY

Only two mines in Kings County have ever reported any production in quicksilver. These two are the Kings mine—at the junction of Kings, Fresno, and Monterey counties; and the Dawson mine about a mile east of the Kings property. The total production for the county is 2001 flasks to the close of 1938.

DAWSON MINE

Location. M. D. M., T. 23 S., R. 16 E., NW¼ Sec. 28, east of Fredana mine, about 9 or 10 miles east of Parkfield.

Ownership. Louis Patriquin, Parkfield, California.

Production History. 1918-1920, 1922-1923, 1925, 1931, 1935-1936, 1939.

There was no production from this property until 1918, although it had previously been discovered by H. Dawson, of Lemoore. In 1919, the property was leased by the Patriquin Mining Company; and a small amount of metal was produced. In 1920, C. E. Jones leased it, but produced only during the months of November and December. The following year, Louis Patriquin, of the Patriquin Mining Company, bought the mine and reported a fair production in 1922, operating until February of 1923. Except for a very short period of production in

1925, the property remained idle until 1931, when it was leased to C. E. Linville who reported a small production for that year. In 1935 and 1936, Frank Carollo leased the mine, and reported a small production for each of those years. A small production was reported during 1939.

General Geology. Similar to that of the Kings property.

Bibliography: State Mineralogist Report XIV, p. 528; XVII, p. 77; XXXI, p. 462. Bulletin 78, p. 50.

FAIRVIEW GROUP

(See under Other Counties and Mines, page 476.)

KINGS MINE (Formerly Table Mountain, and Fredana)

Location. M. D. M., T. 23 S., R. 16 E., Secs. 20 and 30, about 8 or 9 miles due east of Parkfield near the junction of Fresno, Kings, and Monterey Counties. The mine may be reached by road from Parkfield to the west, or from State Highway 33 to the east.

Ownership. Bert Harvey, Parkfield, California.

Production History. This mine takes in the old properties of the Kings Quicksilver mine and the old Table Mountain claim, of Monterey County. The first production recorded at the Kings mine was in 1902. In 1905 and 1910, a few flasks of metal were recovered; but the mine was not developed to a great extent until 1914, when the Kings Quicksilver Mining Company, Ltd., of Ontario, Canada, took it over under bond and erected a 10-ton Scott furnace. The Kings mine operated through 1915 and 1916, and then closed down. The property was taken under option by the Patriquin Brothers, of Parkfield. With the close of the War and the resulting depression, no work was done until 1932, when S. C. Peterson reported a small production under the name of Fredana mine. The Fredana Mining Company, formed in 1932, started operating the mine in 1933, and reduced the ore in pipe retorts. After three years of activity the mine was shut down. At present time, Bert Harvey is operating under name of Kings again. A few flasks were produced by Harvey in 1938 and 1939, using a 2-pipe Johnson-McKay retort.

General Geology. Similar to most of the deposits of this State, the mineralized zone is located near the contact of serpentine and Franciscan metamorphic sandstone. The ore occurs as cinnabar and native mercury in a crushed zone of serpentine, shale, and sandstone.

Bibliography: State Mineralogist Reports XIV, p. 529; XXXI, p. 462. Bulletins 27, p. 124, 78, p. 50. U. S. G. S. Min. Res. 1902, p. 253.

LAKE COUNTY

Lake County has been one of the principal quicksilver producing counties of California for many years, and now ranks fourth in total yield. The total production amounts to 283,264 flasks to the close of 1938.

Bradley states:[1]

"There are four recognized quicksilver districts either wholly or in part located in Lake County. (1) Mayacmas, the largest, is in south-

[1]Bradley, W. W., Quicksilver resources of California: Calif. State Min. Bur. Bull. 78, p. 52, 1918.

western Lake, and extends over into northeastern Sonoma, and northwestern Napa; (2) Clear Lake district is around the eastern, southern, and southwestern sides of Clear Lake; (3) Knoxville district is at the junction of Lake, Yolo, and Napa, being principally in the last named; (4) Sulphur Creek district is almost wholly in Colusa, but includes the Abbott Mine which is on the eastern edge of Lake County."

The largest production has come from the Sulphur Bank mine in the Clear Lake district, with a total of 109,699 flasks to 1937, closely followed by the Great Western with 101,878 flasks, and the Mirabel with 33,524 flasks. Both of the last named are in the Mayacmas district.

ABBOTT MINE

Location. M. D. M., T. 14 N., R. 5 W., NW¼ Sec. 32, in east central Lake County, about 3 miles by road southwest from Wilbur Springs.

Ownership. Mrs. Barber De Bles, Williams, California.

Production History. 1870-1879, 1889-1906, 1916-1919, 1927, 1938- —.

The Abbott mine is a famous old mine of Lake County, having been discovered in 1862. The mine has had two main producing eras. The first was between 1870 and 1879, and the second from 1889 to 1906. During the latter period, it was operated on quite a large scale by the Empire Consolidated Quicksilver Mining Company, with a total production of over 30,000 flasks. R. A. Boggs acquired the property and worked the mine for about one year, starting in 1916 and closing down in 1917. Production for the next two years came from clean-up material around the 48-ton Scott furnace then on the property. A few flasks were reported by Theodore Smith in 1927. The mine is now owned and operated by Mrs. De Bles who reported a few flasks from the cleanup of a Scott furnace in 1938. E. Freels reported a few flasks during 1939.

General Geology. The country rock surrounding the Abbott mine is Franciscan shale and sandstone. Intruded into the Franciscan strata is a belt of serpentine striking northwest, varying in width from a few hundred feet to a quarter of a mile, and about 2½ miles long. Mineralization has occurred in an area of shales intruded by sills of serpentine in a highly crushed and altered state. Occasionally metacinnabar is found, but the main ore mineral is cinnabar associated with pyrite.

Bibliography: State Mineralogist Reports I, p. 360; XI, p. 239; XII, p. 360; XIII, p. 595; XIV, p. 229; XVII, p. 81; XXV, p. 351. Bulletins 27, p. 46; 78, p. 53.

ANDERSON MINE

Location. M. D. M., T. 11 N., R. 8 W., SW¼ Sec. 25. This mine is in the heart of the Mayacmas district, at Anderson Springs, about 4 miles west of Middletown.

Ownership. Dale Strickler, and Albert Baker, Anderson Springs, California.

Production History. 1929, 1932-1933, 1937- —.

Quicksilver deposits were first noted in this vicinity prior to 1917. Nevertheless, it was not until 1929 that any exploration or develop-

ment was done. At that time E. N. Schwartz, of Lakeport, came across an outcrop in the creek bed a short distance below the resort at the springs. He proceeded to sink a small prospect hole, and by 1929 had installed a 12-pipe retort. Schwartz recovered a few flasks in 1929, but operations were not continued. Operation of the property was resumed by Schwartz in 1932, and continued through the following year. The mine remained idle from 1934 to 1937, at which time it was acquired by Dale Strickler. Strickler operated through the summer and fall of 1937, and through 1938 in a locality about a quarter of a mile south and at a higher level than Schwartz's original discovery. He developed an orebody with two adits in the side of the hill, and treated his ore in a D retort.

General Geology. The Anderson mine lies in a region of Franciscan rocks which are typical of the Mayacmas district. The belt or zone of mineralization strikes northwest and extends from the outcrop in the creek bed (mentioned in the preceding paragraph) through the Anderson property and on south through the Big Chief property. This belt has not been explored to any great extent north of Anderson Springs. The mineralization occurs in a highly altered, fractured, and folded greenish sandstone carrying cinnabar, associated with pyrites and calcite, as impregnation, and along seams and fracture planes.

Bibliography: State Mineralogist Reports XVII, p. 81; XXV, p. 351. Bulletins 27, p. 48; 78, p. 55.

BACON CONSOLIDATED GROUP

Location. M. D. M., T. 10 N., R. 8 W., Secs. 11, 12, in the Mayacmas district near the Helen mine. (Partly in Sonoma County.)

Production History. 1876-1877.

This property has been abandoned for many years. It is said to have produced about 300 flasks during the years 1876 and 1877.

Bibliography: Bulletins 27, p. 97; 78, p. 55.

BAKER MINE

Location. M. D. M., T. 12 N., R. 6 W., NW¼ Sec. 16, in the Clear Lake district, about 6 miles by county road southeast from Lower Lake.

Ownership. L. H. Fuqua, Lower Lake, California.

Production History. 1870-1905, 1916-1918, 1930, 1933.

The Baker mine was worked intermittently from the seventies to the turn of the century. Recorded data show a few flasks produced in 1905, but work did not continue into the following year. In 1916, the property was acquired by the Baker Quicksilver Company, with head offices in San Jose, California. The dumps from previous workings were worked over during the first year, with a screening and concentrating plant. In 1917, development with an incline shaft commenced and continued through 1918. In this year the property was shut down and remained idle until 1930. Previous to 1929, the mine had been purchased by L. H. Fuqua, who leased to John Jago in 1930, and to Albert Baker in 1933. All work done during these years was of incidental importance. The property has been idle since 1933.

General Geology. The orebodies of the Baker mine lie on the contact of a serpentine intrusion into Franciscan strata. There are two

orebodies 75 feet apart, striking northwest and dipping northeast, in a highly altered and crushed shale. They vary in width from 10 to 20 ft., and have a length of about 4000 ft. Cinnabar, associated with pyrite and a little metacinnabar, is disseminated through the shale and in occasional high-grade pockets. The ore, in general, is low grade.

Bibliography: State Mineralogist Reports XII, p. 360; XIII, p. 595; XIV, p. 230; XXV, p. 351. Bulletins 27, p. 49; 68, p. 55.

BAXTER MINE

Location. M. D. M., T. 13 N., R. 8 W., Sec. 32, about 6 miles southeast of Kelseyville, just south of the Lucitta mine on the southern slope of Mount Konokti.

Production History. 1917 or 1918.

This mine is little more than a prospect. It was operated by Eugene Wilkenson during the War, and 2 or 3 flasks are reported to have been produced. W. C. Baxter, of Lower Lake, did some development work a few years prior to 1929, but no further production has been reported to the present time.

General Geology. This deposit is cinnabar, found in fractures of rhyolite and obsidian. These flow rocks form the main mass of Mount Konokti, and have been altered to some extent by solfataric action.

Bibliography: State Mineralogist Reports XVII, p. 82; XXV, p. 352.

BIG CHIEF MINE

Location. M. D. M., T. 11 N., R. 8 W., SW¼ Sec. 25 and NE¼ Sec. 35, in the Mayacmas district, about a quarter of a mile south of Anderson Springs, adjoining the Anderson mine.

Ownership. A. Patriquin, Anderson Springs, California.

Production History. 1918, 1920, 1928-1929, 1931-1932.

This property first produced in 1918, when operated by R. B. Crowell, lessee, although cinnabar in the vicinity had been noticed many years before. Crowell did not operate during 1919, but resumed work on a small scale during the year 1920. No further activity of any note took place on the property until 1928, when the Big Chief Mining Corporation, headed by Clarence Lindville, took an option on the mine. This company did considerable development work in blocking out an orebody with adits in the side of the hill, although most of the ore was taken from open cuts. John Andrews installed a small 2 by 20 ft. rotary kiln for the company, but little success was experienced with the furnace. In 1929, the Big Chief Company gave up its bond, and the property remained idle until 1931. At that time L. R. Messer commenced operations, under lease, and he also encountered difficulties with the furnace. It is reported that the inclination and speed of the rotary were so great that a lump of ore passed through in about 5 minutes, and most of the values went out with the partially burned rock. Since 1932, there has been no activity at the mine, but the furnace and condensing system are still on the property.

General Geology. As has been stated, under the discussion of the Anderson mine, the Big Chief orebody is an extension of the Anderson

orebody. The rock formations and ore deposition are identical in the lower workings. In the open cuts at the top of the hill, a difference is found in that cinnabar is disseminated through a highly altered, white, siliceous material containing fragments of metamorphosed sandstone.

Bibliography: State Mineralogist Report XVII, p. 81; XXV, p. 353. Bulletin 78, p. 55.

BIG INJUN MINE

Location. M. D. M., T. 11 N., R. 8 W., Sec. 35, in the Mayacmas district about 7 miles west of Middletown. In good weather this mine can be reached by dirt road from Anderson Springs, a distance of about three miles to the north.

Production History. 1873-?, 1916-1917, 1919.

All the quicksilver from this property was produced prior to 1920. The mine is said to have been discovered by "Injun Jeff" in about 1873. A small amount of work of more or less superficial nature was carried on for a few years. In 1916, R. B. Crowell took an option on the property, and realized a small production during that and the following year. In 1919, Crowell worked over some dump material, and then transferred most of his equipment to the Big Chief mine.

General Geology. The ore occurs at the contact of serpentine and crushed Franciscan sandstone. Minerals are deposited in two zones, each about 30 ft. wide, which strike northwest and dip northeast. The ore is characterized by the presence of native quicksilver in considerable amounts, with cinnabar associated with dolomite and quartz.

Bibliography: State Mineralogist Report XIV, p. 230; XVII, p. 81; XXV, p. 345. Bulletins 27, p. 50; 78, p. 56.

BULLION MINE (See Mirabel mine)

CHICAGO MINE (Formerly Pittsburg, and Ural)

Location. M. D. M., T. 10 N., R. 8 W., SW¼ Sec. 1, in the Mayacmas district half a mile west of the Wall Street mine and just north of the Helen mine. This group of mines lies about 6 miles by country road west of Middletown.

Production History. Pre-1865-?-1911, 1927, 1931-1933.

The history of this old property is rather obscure. That it was known prior to 1865 is certain from J. D. Whitney's [1] report. At this time it was known as the Pittsburg mine, and later the name was changed to Ural mine. Prior to 1903, the present name was given to the mine; and it was operated by the Chicago Quicksilver Mining Company, with head offices in San Jose, California. The mine was abandoned after 1911, and remained idle until 1927. At that time E. J. Wilkinson and his brother resumed activities on a small scale, and produced a small amount of quicksilver. Again, from 1931 through 1933, the Wilkinson brothers reported production. There has been no activity at the mine since that time.

Bibliography: State Mineralogist Reports XIII, p. 593; XIV, p. 230. Bulletins 27, p. 51; 78, p. 58.

[1] Whitney, J. D., Geology of California: Geologic Survey of California, Vol. 1, p. 90, 1865.

GREAT WESTERN MINE

Location. M. D. M., T. 10 N., R. 7 W., Secs. 16, 21, and 22 on the northern slope of Mount St. Helena, at an elevation of over 2000 ft. It lies about 2 miles northwest of the Mirabel mine, and 4 miles, by paved highway and dirt road, southwest of Middletown. This location is in the heart of the Mayacmas district.

Ownership and Staff. Owner: Estate of W. F. Detert; lessee and operator: Bradley Mining Company, 922 Crocker Building, San Francisco, California. Worthen Bradley, president; C. N. Schutte, consulting mining geologist; Bert Mitchell, superintendent.

Production History. 1873-1912, 1915-1916, 1931-1934, 1936-1938.

The Great Western mine was opened up in 1873, and remained a continual producer for more than 35 years. It was operated by the Great Western Quicksilver Mining Company for most of this period, with operations centering in an area which lies to the east and at a slightly lower elevation than the location of the present workings. There were two brick furnaces on the property, one a coarse-ore and the other a Scott furnace. Production began to decrease during 1906, and by 1911 the mine was abandoned as being worked out. In 1912, and again during 1915 and 1916, lessees worked over the old dumps with concentrating devices and managed to produce a small amount, but there was no activity from 1916 to 1931. At that time, E. J. Bumstead organized the Bumstead Mining Company with himself as manager, purchased the mine, and started operations. Bumstead did not attempt to develop the mine through the old entry. Instead, he centered his operations on the western side of the ridge, at a higher elevation than the old shaft and plant. A 20-ton 5-hearth Herreshoff furnace and a modern condensing system were installed, and production was carried on at a moderate rate for 4 years. A temporary shutdown lasted through 1935, and in 1936 the property was leased by the Bradley Mining Company. Operations have been continuous from that date to the end of 1938.

General Geology. The geology of the Great Western mine has been discussed to some extent by Becker,[1] Bradley,[2] and Schutte.[3]

Mineralization occurs at the contact of serpentine and chert. To the south of the contact is a large Tertiary lava flow. There has been considerable brecciation of both the serpentine and chert in the zone of contact, with silicification of the serpentine after brecciation; but apparently no alteration of the chert. The ore formerly mined was found as a cinnabar entirely in the chert in numerous seams and on fracture faces. The present workings definitely lie in a zone of brecciated and silicified serpentine containing cinnabar in cavities and fissures. At least one period of silification after mineralization is shown by samples taken from this orebody. Hydrocarbon compounds are found throughout the mineralized zone.

Mine and Plant. Operations by the Bradley Mining Company are centered in the same general vicinity as those of E. J. Bumstead.

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[1] Becker, G. F. Geology of the quicksilver deposits of the Pacific Slope: U. S. G. S. Mon. 13, p. 358, 1888.

[2] Bradley, W. W., Quicksilver resources of California: Calif. State Min. Bur. Bull. 78, p. 58, 1918.

[3] Schuette, C. N., Occurrence of quicksilver orebodies: A. I. M. E. Trans., pp. 428-429, 1931.

The plant is the same one erected by Bumstead in 1931, with a few alterations and a new condensing system.

Entry to the main workings is by an adit just above the level of the top of the plant. A winze inclined from 25° to 30° connects this main-level adit to an orebody on a lower level, which has been recently opened. The main producing orebody is being stoped just above the level, with use of the square set method of mining. The new stope (known as the No. 9 stope) on the lower level had been mined to a height of about 20 feet, when visited (February 1938). As mining progresses, old workings are occasionally broken into where timbers up to 5 feet in diameter are encountered. Mining is also carried on through an adit situated above the main level. Ore is hauled from this adit to the plant in trucks, as this is deemed less expensive than holing through from the main level and dropping the ore by gravity methods.

Ore from the main workings is hand-trammed through the main-level adit to the primary ore bin of the plant. Here it is dumped over a 2-in. grizzly, where a grizzly-man carefully rejects all oversize waste into a wooden chute and returns the oversize ore to the bin. From the primary bin, the ore passes over a revolving trommel with one-inch round openings. Oversize is crushed to one-inch size in an 8-by 12-in. jaw crusher, then joins the undersize material in a bin at the bottom of the furnace. From this bin it is raised by a chain drive bucket elevator to a fine-ore bin directly over the furnace

The furnace is a 5-hearth Herreshoff of 20-ton capacity. It is fired with 27 gravity Diesel oil, which costs 6.5 cents per gal. Fuel consumption varies from 9 to 12 gallons per ton of ore treated, depending upon the dampness of the ore. Furnace gases pass through a Sirocco dust collector and into the condensing system, of a design similar to that used at the Sulphur Bank mine. This condensing unit consists of three parallel rows of 8-in. diameter vertical pipes joined at the base to inclined tile outlets. The first two vertical pipes in each row are made of steel and air-cooled; the next five are tile and water-cooled by outside sprays; and the remaining eight are tile and air-cooled. Eight parallel inclined outlets discharge mercury and soot to glazed collecting dishes, set in a water-filled launder.

Furnace gases pass from the condensing system into a redwood settling tank, and finally out of a redwood stack set in the tank.

Soot from the condensing unit, after having most of the mercury hoed free, is returned to the drying hearth of the furnace.

The table which follows gives the production costs (exclusive of taxes and insurance) at the Great Western mine for the month of January, 1938.

General Costs for Mining, Milling, Etc., at the Great Western Mine—January, 1938

(*These figures are higher than the monthly average*)

Tonnage treated—22 tons per day, 30 furnace days. Total—664 tons.

Grade of ore mined—12.2 lbs. per ton.

Grade of ore furnaced—15.1 lbs. per ton.

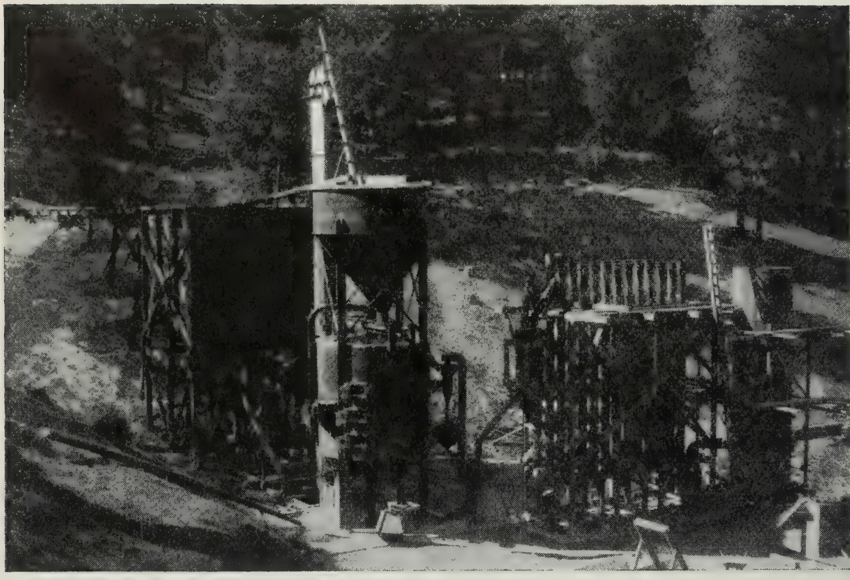

FIG. 3. Herreshoff furnace and original condensing system being installed at the Great Western Mine, Lake County. Mine portal to left of picture.
Photo by George E. Connolly (taken 1931).

FIG. 4. Hereshoff furnace reduction plant at the Great Western Mine, Lake County. The mine portal is to the right of the picture; mine dump in right foreground.

Per cent waste sorted out—18.8.
Flasks produced—132.

Item	*Cost per ton handled*	*Cost per ton furnaced*
Development	$1.16	$1.60
Mining	1.32	1.83
Reduction	1.44	1.98
Sorting	.14	.19
Miscellaneous work	.13	.18
Overhead	.32	.45
Selling expense	.07	.10
	$4.58	$6.33

Bibliography: State Mineralogist Reports I, IV, VI, VIII, XII, XIII, XIV, XVII, XXV. Bulletins 27, p. 62; 78, p. 58.

HAYS MINE

(See under OTHER COUNTIES AND MINES, page 476.)

HELEN MINE (formerly Dead Broke, and American)

Location. M. D. M., T. 10 N., R. 8 W., SW$\frac{1}{4}$ Sec. 1, about 6 miles by county road west of Middletown, in the Mayacmas district. To the north is the Chicago mine, and to the northwest is the Wall Street mine, both within a mile.

Ownership. H. W. Gould, San Francisco, California. Leased to L. S. Peterson, Middletown, California.

Production History. 1873-?, 1902-1905, 1907-1924, 1926, 1928-1929, 1932-1937, 1939.

The first recorded production from this property was made in 1873, and the claims were patented the following year. The mine has been a very consistent, although not a particularly large, producer to the present time, with a total recorded yield to 1939 of over 6000 flasks. (Total output claimed to be 16,000 flasks.) The property was first worked by one Puchbecker who later sold to the American Mining Company. In 1900, Andrew Rocca, Sr., purchased the mine and began production two years later, after doing some development work. Rocca operated here for more than 20 years, using a 50-ton Scott furnace to treat the ore and a retort for the soot from the condensing system. In 1924, the Pacific Coast Mines Development Company installed a 30 by 40 ft. rotary furnace and operated the property for a short time. In 1926, the mine was operated under lease by the Mineral Mountain Mines Company, and a small production was realized. H. W. Gould purchased the property from Rocca in 1927, and leased to L. S. Peterson in 1928. With a few interruptions, Peterson has been producing a small amount of metal each year until 1937. Although not operating during 1938, a few flasks were produced in 1939. He uses a D retort to treat the ore.

General Geology. The Helen mine lies on the contact of serpentine and Franciscan sandstone. Movement along the contact zone has brecciated the serpentine to some extent, and has formed a gouge on the hangingwall of the fault. The footwall is serpentine which has been silicified to a great extent, and contains lenses of black opaline material. Beyond the gouge on the hangingwall is an area of sandstone. There are 3 orebodies in a general zone which has a NW. strike, and a 30°-35°

SE. dip. Two of the orebodies are in the serpentine along the hanging-wall, and the third lies vertically in the serpentine. These ore shoots vary in width from 5 ft. to 10 ft. and are about 70 to 100 feet long. Cinnabar occurs in the brecciated silicified serpentine in seams of an inch or two in thickness, roughly paralleling the strike of the ore zone.

Bibliography: State Mineralogist Reports XII, p. 360; XIII, p. 595; XIV, p. 231; XVII, p. 81; XXV, p. 355. Bulletins 27, p. 55; 78, p. 59.

LUCITTA MINE (Formerly Uncle Sam; sometimes called Konokti)

Location. M. D. M., T. 13 N., R. 8 W., Secs. 20 and 21, about 7 miles southeast of Kelseyville on the southern slope of Mount Konokti.

Ownership. John L. Jago.

Production History. 1880-?, 1902, 1929, 1932.

The date of discovery of this mine is uncertain, but it was considered no more than a prospect until 1902. At that time G. W. Pardee exploited the property, and recovered a few flasks. Pardee sold the mine to T. A. Bell in 1907, but no production was recorded. The mine remained idle until 1929, at which time it was bought for taxes by John Jago. No further activity has taken place to the present time with the exception of a few flasks produced in 1932.

General Geology. Cinnabar occurs at the mine as a coating on andesite boulders, and in a decomposed tuff which has been bleached by solfataric action.

Bibliography: State Mineralogist Report V, p. 96; XIV, p. 233; XVII, p. 91; XXV, p. 350; Bulletin 27, p. 58; 78, p. 61.

MAYPOLE PROSPECT

(See under Other Counties and Mines, page 476.)

MIDDLETOWN PROSPECT

(See under Other Counties, 476.)

MIRABEL MINE (Formerly Bradford) (Including Bullion mine)

Location. M. D. M., T. 10 N., R. 7 W., Secs. 14, 22 (Bullion), and 23, about 4 miles by paved highway south of Middletown. State Highway No. 29 runs directly through the property.

Ownership. Mirabel Quicksilver Mining Company, office at the mine. W. E. Best, president; Thomas O'Connor, superintendent.

Production History. 1870's (?), 1887-1903, 1908-1916, 1928-—.

The Mirabel mine has an interesting history which is revealed in a private report by J. McL. Harvey, former agent for the Standard Quicksilver Company. Mr. W. E. Best, president of the present operating company, was kind enough to allow the authors to read this report from which are presented the following facts:

In the early seventies a cinnabar deposit was noted in the vicinity of the existing property and subsequently named the Great Eastern mine. On this claim the major workings are located today. A shaft was sunk near the creek bed, but it was soon flooded and the mine was abandoned. In 1887, an early Lake County settler named Bradford ran across cinnabar float on his property, in the bottom of St. Helena

Creek, a short distance below the Great Eastern mine. Some time later, while reputedly sinking a well, he hit a large body of cinnabar. Bradford and his sons operated the newly discovered mine for about six years. In 1893, three men (by name: Mills, Randol, and Bell) formed the Standard Quicksilver Company. They purchased the mine for a reported price of $750,000, renamed it the Mirabel mine, and commenced operations on a large scale. Two furnaces were constructed, one a coarse-ore furnace of 15 tons capacity and the other a Scott fine-ore furnace of 48 tons capacity. The Scott furnace is still standing and in good condition. The Standard Company owned about 750 acres of land patented by Bradford, including the Plymouth claim, the Great Eastern claim, the Mirabel proper, and the Bullion claim. Operations continued for a period of 5 years; but by 1897, the ore reserves were gone and the Mirabel was abandoned as worked out. Operations continued on a small scale at the Bullion property, but it was abandoned in 1903. A period of idleness ensued which lasted nearly 25 years, and was broken only by a few lessees in 1908, 1914, and 1916, who cleaned up a few flasks around the dumps and furnaces. In 1928, H. C. and L. H. Davey and John W. Doman took a lease on the property with an option to buy, and entered on an extensive development program. Only the ore which was the result of development was treated. The Mirabel Quicksilver Mining Company was then formed, with H. C. Davey as superintendent, and the property was purchased in 1929. Actual operations, under this company, began in 1930 and have been continuous to the present time. Early in 1934, W. E. Best was named president of the company, and he took charge at the mine that year.

General Geology. The ore at the Mirabel mine is found in lenses of silicified serpentine; the occurrence of the cinnabar is similar in many respects to the deposits of the more recent workings of the Great Western mine. The main points of similarity are: (1) the general silicified character of the ledge material; (2) the occurrence of hydrocarbons associated with mineral deposition (the presence of these hydrocarbons is considered a good guide to ore in both deposits); and (3) the fact that ore deposition has occurred in both cases, either on the contact of, or in, the serpentine as distinct mineralized zones. In the zones at the Mirabel mine, the cinnabar is found primarily as fissure fillings in a series of small, irregular veins and as a breccia filling. Frequently native quicksilver, and occasionally metacinnabar, is found associated with the cinnabar. Dolomite, often well crystallized, is prominent as a gangue mineral.

The deposits of the Great Western mine lie near or on the contact of serpentine and chert; whereas the deposits of the Mirabel mine are located at the contact of serpentine with Franciscan sandstones and shales.

Mine and Plant. The mine is now being worked in two separate areas. The principal workings are in the old Great Eastern orebody, just east of St. Helena Creek. About a quarter of a mile farther north, on the west side of the creek, and just west of the highway, is the entry to the second workings which are in the old Mirabel orebody. The Great Eastern orebody is developed by a single-compartment 350-ft. vertical shaft and an inclined winze of about 45° dip, sunk to the 465-ft. level. An intervening level between the 350-ft. level and

the surface is the 275-ft level. There are three main stopes, known as No. 1, No. 2, and No. 3 respectively. Number 1 and No. 2 are practically mined out. Number 3 is approaching a depth of 500 ft. below the original outcrop, and it is thought by Thomas O'Connor, general superintendent, that little ore will be recovered from this stope at further depth, as the ore shoot is apparently splitting and dropping in grade. All the mining is done by the open stope method, as the ground holds well, and there is little need for timber. Ore is hoisted in skips up the winze to the 350-ft. level, and then hand trammed to the vertical shaft. Here it is hoisted by single 13 cu. ft. car loads in a cage, and dumped in a 50 ton primary bin at the surface. Hoisting in each case is done by a single-drum electric hoist.

An extensive development program is being carried on in the Mirabel orebody. The old two-compartment Mirabel shaft appeared to be caved at the time the present owners took over the mine, so an inclined shaft was sunk through an old filled stope about 500 ft. north of the Mirabel shaft, in order to afford a new entry to the mine. An old level was encountered at a vertical depth of about 100 ft. This was cleaned out as far back as the main shaft. Subsequent inspection revealed that only the first few sets below the collar of this shaft were caved, and that the rest of the shaft was in excellent condition. A good orebody on this level is now being mined by shrinkage stoping. Further development is being carried on through an inclined winze from the 100-ft. level, but as yet, no ore is being mined below this level. Ore is now removed through the incline shaft in a bucket which runs on wooden guides, and is hoisted by a small steam engine which has been converted to use compressed air. At the surface the ore is dumped into a truck, in which it is hauled to the plant.

The plant is situated at the collar of the Great Eastern shaft. Ore is crushed in a No. 2 gyratory crusher (set $\frac{3}{4}$-in.) below the primary ore bin, and is fed to a fine-ore bin. It is then fed to a rotary furnace by means of a 6-in. Selway rotary feeder, which consists of a revolving pipe from a small hopper extending into the furnace at the upper end. The rotary furnace is 30 ft. long by 30 in. inside diameter and has a rated capacity of 25 tons per 24 hours. It is set on a slope of one in. per linear foot, and revolves at a speed of about 2-2$\frac{1}{2}$ r.p.m. An 18 gravity fuel oil is used to fire the furnace, with an average consumption of from 11 to 12 gallons per ton of ore treated. Furnace gases pass through an 8-in. Sirocco dust collector into the condensing unit which is made up of ten 16 in. diameter steel pipes a quarter of an inch thick and 18 ft. long. From 2 baffled redwood settling tanks the gases pass through about 200 ft. of 16-in. tile pipe to the stack, which is situated some 75 ft. away, up the hill. Soot and mercury from the condensing system is hoed with unslaked lime on a table set up under a ventilating hood, and the remaining soot is returned to the feed end of the furnace. Calcined ore is dropped into a small concrete bin, below the firing end of the furnace, and is hauled up an inclined ramp in cars by means of a small air tugger. The ore is dumped near the creek, where high water washes most of it away.

The entire system of furnace and condensing units is kept under close control as to temperature and draft, at the critical points, by a series of recording pyrometers and U-tube manometers.

Bibliography: State Mineralogist Reports XI, p. 64; XII, p. 361; XIII, p. 596; XIV, p. 233; XXV, p. 357. Bulletins 27, p. 60; 78, p. 62. Mining World, Vol. 1, No. 3, 1939, p. 9.

RED ELEPHANT MINE

Location. M. D. M., T. 11 N., R. 5 W., Sec. 3, in the Knoxville district, very near the Napa County line, about 20 miles by county road southeast of Lower Lake. The mine lies about half a mile west of the Knoxville property.

Ownership. Red Elephant Quicksilver Mining Company, San Francisco, California. A. Gradine, San Francisco.

Production History. 1922-1931, 1934-1935.

This mine has been known as a prospect since its location in 1898, although it was not until 1929 that any metal was produced. In 1918, the property was acquired by the Red Elephant Quicksilver Mining Company, which did a considerable amount of development work but did not install any reduction equipment. In 1929, a five-year lease was let to F. D. Sanders, of San Francisco. He installed a small rotary furnace measuring 16 ft. in length and 4 ft. 6 in. in diameter. Sanders operated through the year 1931, and then gave up his lease. The Big Six Mining Company leased the property in 1934, and produced in a small way for 2 years. The mine and plant are now idle. Total production to 1937 amounts to 354 flasks.

General Geology. The country rock of the Red Elephant mine is serpentine in which are found stringers of cinnabar from 1 to 2 in. wide..

Bibliography: State Mineralogist Reports XIV, p. 234; XVII, p. 82; XXV, p. 358. Bulletins 27, p. 92; 78, p. 62.

RED ROCK AND SILVER ROCK CLAIMS

(See under Other Counties and Mines, page 476.)

RICH HILL PROSPECT

(See under Other Counties and Mines, page 476.)

SHAMROCK PROSPECT

(See under Other Counties and Mines, page 476.)

SULPHUR BANK MINE

Location. M. D. M., T. 13 N., R. 7 W., Sec. 6. The Sulphur Bank mine lies on the southeast shore of Clear Lake in the Clear Lake district. The town of Lower Lake is about 10 miles to the south, and State Highway No. 20 passes the mine about 2 miles to the east. Approximately 800 acres of land are held by the present operators.

Ownership and Staff. Owner: Estate of G. T. Ruddock; lessee and operator: Bradley Mining Company, 922 Crocker Building, San Francisco. Worthen Bradley, president; A. F. Wolbert, superintendent.

Production History. 1873-1883, 1887-1897, 1899-1902, 1915-1918, 1927- —.

The early history of the mine dates back to 1865, when the deposit was exploited for the free sulphur present by the California Borax Company. This company found that at a depth below the sulphur-

bearing horizon, the amount of cinnabar present made refining of the sulphur extremely difficult and expensive. In 1868, a rapid fall in the price of sulphur caused the company to cease operations. Interest in quicksilver began to increase with the boom prices of the seventies, and the California Borax Company decided to capitalize on their previously troublesome by-product. Production of quicksilver started in 1873, and continued steadily for a 10 year period, at the end of which period a decreasing price for the metal caused a second shut down. Four years later the mine was reopened by the Sulphur Bank Quicksilver Mining Company, and they operated for a 10 year period. The Empire Consolidated Mining Company took over the mine in 1899, and produced a little metal until 1902.

During these early years of production, the ore was mined from open cuts and from underground workings. Because of the presence of sulphur dioxide fumes and high underground heat, it is difficult to conceive how miners were able to accomplish anything while working underground. It is said that the men worked in 20 minute shifts, and were constantly sprayed with water while in the mine. Ore was reduced in a 25-ton Knox-Osborne furnace, three Scott furnaces of 40, 30, and 17 tons capacity, and a battery of D retorts.

There was no activity on the property from 1902 until 1915. At this time the Sulphur Bank Association, of San Francisco, acquired the property under lease and bond, and began doing some surface work which lasted through the War period. The ore mined was treated in retorts during this period. A rotary furnace was installed in 1918, but was operated only a short time. Following the War the mine was idle until 1927. Since 1927 production has been continuous.

General Geology. Sulphur Bank is a low, rounded hill on the shore of Clear Lake, and is situated in an area of Franciscan rocks overlain by a series of fresh-water sediments of Pliocene-Pleistocene age capped by a Pleistocene basalt flow. The sediments (frequently referred to as Cache Lake beds) consist of flat-lying sands and conglomerates deposited on a series of horizontal Franciscan shales and sandstones. A basalt extrusion broke through the overlying sedimentary strata, possibly at a point near the shore of Clear Lake, and spread out in a sheet over the sediments. Upon cooling, this basalt developed shrinkage cracks, and formed the well known pillow structure commonly found in extrusive rocks which have been cooled under water. Solfataric action has altered the rock to a great extent, with concentric weathering of the basalt common throughout the deposit.

A thrust fault strikes approximately east-west across the southern extent of the mine workings. Through rifts in the hanging, or north wall, hot sulphurous waters and steam now escape. The mineralizing solutions that probably rose through these rifts, were to a certain degree trapped by the overlying basalt, and deposited cinnabar at this point. The basalt sheet is not very extensive, being bound on the north and west by the waters of Clear Lake. To the south it may have been faulted off with the faulted section eroded away, or it may have stopped in its flow before reaching the fault zone.

Cinnabar occurs closely associated with the basalt and, at depth, it is said to have been deposited in the fractured sedimentary rocks. The principal occurrence is in an altered material which has filled the

shrinkage cracks between the basalt pillows. Frequently it is found as fracture fillings of the rock, and several cases were noted where the cinnabar has actually impregnated the basalt.

Ore is found in commercial quantities from a depth of 30 or 40 feet below the surface level to the lowest workings, which are more than 150 feet deep. The upper horizon contained sulphur in commercial

FIG. 5. Steam and mud fumerole, Sulphur Bank Mine, Lake County. This particular vent is one of many active hot springs in the widespread thermal area.

quantities, and it was mined during the first years of operations. Sulphur is still a plentiful and closely associated mineral. Boiling hot springs are numerous throughout the area, and in one case action is of sufficient violence to throw a continual spray of mud and water into the air. It is quite certain that mineralization is proceeding at the present time in many of the springs and steam vents.

Mine and Plant. Mining at the Sulphur Bank is done entirely in open pits. The superintendent at the mine (A. Wolbert) stated that a short drift was run not long ago, and before it had reached 50 ft. in length the heat was so intense that, regardless of the fact that air under forced draft was delivered constantly to the face, the men were unable to work for more than half-hour periods. This situation soon caused the management to give up the project. Evidence of former mining activities on the property is noticeable over an area of about 100 acres. Old shafts, pits, and trenches are too numerous to be mentioned separately. The present mining activities are centered in Parrot Pit, which has been excavated to a depth of 80 or 90 ft. below the level of the surrounding terrain. In the bottom of the pit is a power shovel of one cu. yd. capacity, operated by a 75 h.p. Diesel motor. This shovel loads ore into trucks, the newest one being a 10 cu. yd. truck powered by a

250 h.p. Diesel motor. Two men stand in the back of the truck as it is being loaded, and sort out the large pieces of waste. At a higher elevation in this same pit, selective mining is being done by men who hand shovel the high grade material that is found between basalt boulders into the bucket of a second power shovel, identical in size to the one previously described. The selected ore is loaded into trucks and transported to the plant, about half a mile distant.

Ore from the mine is dumped through a grizzly into a primary ore bin. A 10 by 20 in. Blake jaw crusher breaks the oversize rock to about 2-in. size. It is then transported by a series of conveyor belts to a hopper at the upper end of a 5 by 60 ft. rotary furnace. As the ore drops from the conveyor belt to the hopper, the stream is cut at 5 minute intervals by an automatic device which diverts the flow into a sample box. Feed to the kiln is purely by gravity methods, and back spilling is prevented by a set of 6 helical blades 2 ft. long, arranged inside the furnace to carry the ore away from the the feed end.

The firing of the furnace at Sulphur Bank is unique in modern metallurgical practices. Because of the high sulphur content in the ore treated, it was found that in order to get complete combustion of sulphur, the firing must be done at the feed end of the furnace. With good temperature control no unburned sulphur vapors now enter the stream; and, consequently, there is no recombination of mercury and

FIG. 6. Sulphur Bank Mine (Parrot Pit), Lake County, Clear Lake in background.

sulphur in the condensing system. Fuel oil used for firing is a 19 gravity oil, and the consumption for the year 1937 averaged 12.95 gal. per wet ton of ore treated. The rotary furnace, when first built, had a diameter of 5 ft. and was only 40 ft. long. Later a 20 ft. section was added, with a view to increasing the tonnage. The capacity, however, was not increased despite the fact that the furnace became more effi-

cient at burning out the sulphur. It is set at a slope of half an inch to the linear foot, and rotates about 1½ to 2 r.p.m. The method of disposal of calcined ore is quite interesting. From the lower end of the furnace it is sluiced by a continual flow of water in a trough to a drag line. It is then scraped to the end of a long dump by a V-shaped scraper.

Gases leave the furnace and enter a Sirocco dust collector at a temperature of 1155° F. (625° C.) and because of this exceptional heat, a very large and complicated condensing system is required. The primary unit consists of three parallel rows of mild steel vertical pipes, 10 in. in diameter and 26 ft. high, with 6 pipes per row. This is followed by 5 parallel rows of steel vertical pipes, 10 in. in diameter and 9 ft. high, with 5 pipes per row; and 5 parallel rows of vertical tile pipes, 10 in. in diameter and 9 ft. high, with 12 pipes per row. This gives a total of 103 pipes. The unit was designed by C. N. Schuette, and is similar to the one used at the Great Western mine. The vertical pipes join inclined tile outlets at the base, which deliver mercury and soot to wooden pails and boxes. The gases pass from the primary unit into a secondary unit which is the one described by Worthen Bradley [1] in U. S. Bureau of Mines Information Circular 6429. This unit consists of a series of wooden tanks and spray towers washed by a continuous flow of water, which gives a low grade mud recovery. At the end of the system is a 48 in. wooden stack, 40 ft. in length.

The low grade mud from the secondary unit is sent to 2 thickeners. The partially dewatered product is pumped to an agitator, whence it is sent to a 2-cell flotation unit. The concentrates are filtered, dried, and retorted in one double, oil-fired D retort. Soot and mercury which are collected from the primary system are mechanically agitated with unslaked lime, and the remaining mud joins the flotation concentrates in the retorts.

A large flotation plant was installed in 1928, on a hill to the rear of the present mill. If successful, the plant was to treat about 500 tons per day. So many difficulties were encountered, however, that the plant proved to be of but limited success. It is probable that the chief trouble lay in the ever-changing type of ore which was encountered. The plant could not be adjusted rapidly enough to handle these day-to-day changes. Moreover, there was a problem on the subject of the treatment of the concentrates. The cinnabar was so finely divided through the concentrate that it was extremely difficult to make a good extraction in the rotary; at the same time, the grade of the concentrate was not high enough to warrant treatment by retorts. The plant now lies partly dismantled.

The following table gives the mining, reduction, and general expense costs for the year 1937.

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[1] Bradley, Worthen, Method and cost of recovering quicksilver from low grade ore at the reduction plant of the Sulphur Bank Syndicate: U. S. Bur. Mines Information Circular 6429, pp. 7-8, 1931.

General Costs for Mining, Milling, Etc., at the Sulphur Bank Mine—1937 [1]

Flasks produced—2519.
Tonnage treated—25,398.40 wet tons.

Item	Cost per ton	Total cost
Operating Expense:		
Surface mining	$1.588	$40,325.20
Plant operation	1.705	43,326.35
Power	.339	8,624.41
General expense (S. F. overhead)	.238	6,033.63
Marketing	.338	8,580.45
Camp upkeep	.100	2,547.24
Capital expense	.408	10,376.94
Total	$4.303	$119,832.31

Bibliography: State Mineralogist Reports I, IV, V, VI, VIII, XII, XIII, XIV, XVII, XXV. Bulletins 27, p. 61; 78, p. 63. (Other earlier references are obtainable from the bibliographical list in Bull. 78.)

THORN MINE (Formerly Bear Canyon)

Location. M. D. M., T. 11 N., R. 8 W., NW¼ Sec. 36, about 4 miles west from Middletown, and about one mile southeast of the Big Chief mine in the Mayacmas district.

Ownership. Charles and Dave Thorn, Middletown, California.

Production History. 1909-?-1929.

In the year 1909, a small production at this property, then known as the Bear Canyon, was realized from ore taken out by development work. Since that time it has been operated sporadically by the Thorn brothers, with about 500 flasks total production up to 1929.

General Geology. Similar to that of the Big Chief and Anderson mines.

Bibliography: State Mineralogist Reports XIV, p. 238; XVII, p. 82; XXV, p. 363. Bulletins 27, p. 70; 78, p. 68.

UTOPIA MINE

Location. M. D. M., T. 15 N., R. 9 W., Sec. 25. On the eastern shore of Clear Lake, near Bartlett Landing.

Ownership. Last reported owner (1918), Utopia Quicksilver Mining Company of Lakeport.

Production History. Some production of quicksilver has been reported from this mine but it has not been operated for about 25 years.

Bibliography: State Mineralogist Reports XIII, p. 597; XIV, p. 239. Bulletin 27, p. 70; 78, p. 68.

WALL STREET MINE (Formerly Cincinnati) (Including Jewess Prospect)

Location. M. D. M., T. 10 N., R. 8 W., SE¼ Sec. 1, about 5 miles west of Middletown and half a mile east of the Helen mine.

Ownership. American Quicksilver Company. Ira Merrill, general manager (1926).

Production History. 1875-1878, 1905-1923, 1926.

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[1] Exclusive of insurance and taxes.

First recorded production on this property was made about 1875, at which time the land was patented. The mine was closed in 1878, and later abandoned. W. H. Parsons acquired title to the property in 1898 by the payment of delinquent taxes. Parsons commenced producing in 1905, and for a period of 18 years he reported a small production each year. He sold to the American Quicksilver Mining Company in 1924. The new owners did some development work, and installed a small rotary furnace of 15 tons capacity. Sixty flasks of quicksilver were recovered in 1926, but no further production has been recorded. It is reported that the property was deeded to the State for delinquent taxes, in 1931.

General Geology. The Wall Street mine lies, apparently, in a faulted section of the Helen orebody, which is worked about half a mile to the west. The ore-bearing ledge is in serpentine, strikes northwest and dips about 30° southwest. Cinnabar occurs in vugs and seams in a quartz vein, as well as in the highly brecciated serpentine on the foot-wall. A considerable quantity of native quicksilver has been noted in this mine, a characteristic not so common at the Helen mine.

Bibliography: State Mineralogist Reports I, p. 27; V, p. 96; XII, p. 362; XIV, p. 237; XVII, p. 82; XXV, p. 363. Bulletins 27, p. 71; 78, p. 69.

WHITE ELEPHANT PROSPECT

(See under Other Counties and Mines, page 476.)

LOS ANGELES COUNTY

(See under Other Counties and Mines, page 476.)

MARIN COUNTY

(See under Other Counties and Mines, page 476.)

MARIPOSA COUNTY

(See under Other Counties and Mines, page 476.)

MENDOCINO COUNTY

OCCIDENT MINE (Originally Amarillo; also known as Wise's mine)

Location. M. D. M., T. 12 N., R. 11 W., Sec. 6, about 7 miles southwest of Hopland.

Ownership. Last reported owner (1918), W. H. M. Smallman, San Francisco.

Production History. 1906.

Some work was done on this property in 1875, and again for several years preceding 1907. The only definite record of commercial output is 50 flasks in 1906. There has been no work done since.

General Geology. The ore is in an ocherous, weathered serpentine material, similar to that found at many of the California quicksilver mines.

Bibliography: Min. Res. W. of Rocky Mts., 1875, p. 14. U. S. G. S. Min. Res., 1906, p. 492; 1907, Part I, p. 679. Cal. State Min. Bur. Bull. 78, p. 71.

MERCED COUNTY

RED METAL MINE

Location. M. D. M., T. 11 S., R. 7 E., Sec. 32, at base of Crown Point Peak.

Production History. 1888?

It is reported that this mine yielded sufficient cinnabar to amply repay for all the labor. The ore was reduced at the works of the adjoining Gypsy Mining Company (later Stayton mine).

General Geology. The ore occurred in a quartzitic gangue, and included some antimony. The richest cinnabar was found in seams and pockets running through the ledge.

Bibliography: State Mineralogist Report VIII, p. 350.

MODOC COUNTY

There has been no production recorded in Modoc County since W. W. Bradley's bulletin was published in 1918. The only deposit from which any production has been made is located in T. 46 N., R. 15 E., Sec. 18, about 3½ miles southeast of Willow Ranch station. This deposit is known as the Modoc Cinnabar group.

Bradley states of it: [1]

> "The country rock is stated to be volcanic, and the vein of soft gouge-like material 18-20 inches wide, carrying cinnabar."

MONO COUNTY

(See under Other Counties and Mines, page 476.)

MONTEREY COUNTY

Monterey County ranks with Fresno and Kings Counties in regard to production. There has been only one mine of economic importance in the county, the Patriquin mine, located near the junction of Monterey, Kings, and Fresno Counties.

The total production from the county, to the close of 1938, is 1425 flasks.

DUTRO MINE

(See under Other Counties and Mines, page 476.)

GILLETTE MINE (Formerly Patriquin-Gillette)

Location. M. D. M., T. 23 S., R. 14 E., Sec. 1, about 5½ miles by road north of Parkfield.

Ownership. N. Gillette, Coalinga.

Production History. 1917, 1937-—.

In 1917, a D retort was installed on this property by the Patriquin Brothers, lessees. A few flasks of quicksilver were recovered that year, but the mine has been idle since that time except for sporadic small production during recent years.

General Geology. The Gillette mine lies on the southeasterly extension of the Patriquin ore zone (see Patriquin mine).

Bibliography: Bulletin 78, p. 73.

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[1] Bradley, W. W., Quicksilver resources of California: Calif. State Min. Bur. Bull. 78, p. 72, 1918.

G. W. D. MINE *

Location. M. D. M., T. 23 S., R. 14 E., Sec. 2, about 4½ miles north of Parkfield.

Ownership. Leased by N. Gillette, Coalinga, T. E. Washburn, Box 785, Coalinga, and G. H. Day.

Production History. The G. W. D. property, consisting of 120 acres, is a new prospect and has produced only 23 flasks of quicksilver during short periods in the years 1937 and 1939, using a small 2-pipe retort.

General Geology. Cinnabar occurs chiefly in sandstone in a serpentine-sandstone contact zone. Mr. Washburn reports that there is considerable tonnage of low-grade ore. The high-grade material occurs in pockets.

MONTE CRISTO GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

PATRIQUIN MINE (Formerly Pitts, Cholame, and Parkfield, respectively)

Location. M. D. M., T. 23 S., R. 14 N., Sec. 2, about 6 miles by county road north of Parkfield.

Ownership. Franciscan Mining Co., Monterey, California.

Production History. 1873, 1915-1918, 1920, 1922-1925, 1927, 1930, 1934-1939.

The first operations at this mine were in 1873, by a man named Pitts who produced about 60 flasks of quicksilver that year, and then abandoned the property. Activity on the property resumed in 1913, when the mine (then known as Parkfield mine) was opened up by a lessee. About $6000 worth of development work was done, but no ore was treated. In 1915, the property was acquired by A. G. Patriquin, Mrs. L. S. Patriquin, and J. W. B. Anderson. After three years of steady operation, the owners closed the mine in 1918. The Master Mining Company purchased the property in 1922, and installed a furnace of their own design. The ore treated in this furnace yielded a few flasks in 1922 and 1923. In 1924, the mine was purchased by the Franciscan Mining Company, which installed a 60-ton rotary furnace and began production by the end of that year. Operations were continuous through 1925, and again in 1927. Since that time there have been various lessees on the property reporting a few flasks in the consecutive years 1934 to 1938. The use of butane gas for firing the furnace was experimented with at this mine in 1934; due to a temporary shut down of the mine, however, the experiment was discontinued a few months after it started. In 1938, Mr. O. W. Irwin, Monterey, California, operated the property during the year for a short period. During 1939 a small production was reported resulting from experiments with a new furnace installation.

General Geology. The country rocks surrounding the Patriquin mine consist of serpentine and Franciscan sandstone. Cutting these rocks is a series of parallel veins of quartz, opal, and chalcedony carrying the ore values as cinnabar and metacinnabar. Between the veins, the intervening sandstone is generally impregnated with cinnabar.

* Information concerning this mine was obtained from a personal communication with Mr. Washburn.

Bibliography: State Mineralogist Report XV, p. 613; XVII, p. 77; XVIII, p. 424; XXI, p. 51; XXXI, p. 462. Bulletins 27, p. 123; 78, p. 73.

POPPY MINE *

Location. M. D. M., T. 23 S., R. 14 E., Sec. 2, about 4½ miles north of Parkfield adjoining the G. W. D. mine.

Ownership. N. Gillette, and T. E. Washburn, Box 785, Coalinga, California.

Production History. The Poppy mine has produced only a small amount of quicksilver (3 flasks in 1932) by the use of a pipe retort.

General Geology. Similar to that of the G. W. D. mine.

TABLE MOUNTAIN CLAIM

Location. M. D. M., T. 23 S., R. 16 E., Sec. 30, 9 miles east of Parkfield.

Ownership. Last reported owner (1918), G. W. White, Parkfield.

Production History. 1916. Two or three flasks of quicksilver were produced from a 12-pipe retort.

General Geology. Cinnabar occurs with opaline silica in serpentine.

Bibliography: State Mineralogist Report XV, p. 614. Bulletins 27, p. 124; 78, p. 75.

NAPA COUNTY

Quicksilver deposits have been known in Napa County since the fifties and sixties, when the Aetna and Knoxville mines were discovered. Production has waned during the past few years, but the total yield of 352,075 flasks to the end of 1938 places this county third among the counties of California for total quicksilver production.

There are two major producing areas and one minor district within the county. Where Yolo, Lake, and Napa Counties join is the Knoxville district, containing the Knoxville and Manhattan mines and some smaller properties. The southeast extension of the Mayacmas district lies within Napa County, and here are located several large producers including the Oat Hill, Aetna, and Corona mines. To the south, on the west side of Napa Valley, is a small district containing the Bella Oaks and La Joya mines.

AETNA MINE (Formerly Pope Valley)

Location. M. D. M., T. 9 N., R. 6 W., Secs. 2 and 3. This mine is at Aetna Springs, about 9 miles by county road northeast of Calistoga. The mine property lies on a ridge separating the head of Pope Creek from James Creek, about 2 miles southeast of the Oat Hill mine.

Ownership. Aetna Quicksilver Mining Company, and Estate of Charles A. Gray, San Francisco, California. Leased to J. F. Knapp Corporation, Oakland, California.

Production History. 1863, 1868-1880, 1884-1888, 1890-1901, 1903-1904, 1910, 1912-1918, 1921, 1925-1927, 1929, 1931-1936, 1938-—.

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* Information concerning this mine was obtained from a personal communication with Mr. Gillette.

Discovery of this mine is credited to a man named Lawley, in 1854; and production commenced in 1863 under the control of the Hamilton Quicksilver Mining Company. Haufmeister, et al., purchased the property in 1884, and operated to 1888, after which time it was sold to the Aetna Consolidated Quicksilver Company. A long and important period of production was started at this time which lasted to 1904, with

FIG. 7. Aetna Mine, Napa County. Mine portal just off picture to the right; furnace plant center; concentration plant to left of condenser tanks.

a gradual tapering off in operations during the later years. The Lawley brothers purchased the property in 1904, reporting a small yield that year and also in 1910 and 1912. Bor Soderhjelm leased the mine from 1913 to 1915, and installed a concentrating mill which was also operated by other interests from 1916 to 1918. Since the War, operations have been extremely sporadic, with various lessees on the property from time to time. George Patrick reported a few flasks in 1921. In 1925, the property was acquired by the present owners, the Aetna Quicksilver Mining Company. Several lessees have operated at intervals up to the present time. A rotary furnace was installed in 1926, which has been operated only occasionally. Joseph Garcia and Andrew Rocca, Jr., leased the property in 1937. The Knapp Corporation is the present leaser and operator (1939).

General Geology. The rocks surrounding the Aetna mine consist of serpentine, Franciscan sandstone, basalt, and tuff. According to Forstner,[1] the serpentine overlies Franciscan strata of sandstone which

[1] Forstner, Wm., Quicksilver resources of California. Calif. State Min. Bur. Bull. 27, pp. 72-76. 1903.

has been cut by a basalt dike. A siliceous tuff surrounds the basalt and overlies the sandstone.

Cinnabar occurs in a recemented sandstone-brecca with an opaline gangue. It is found, in some places, as paint on the fracture faces of brecciated rock.

Mine and Plant. There are five patented claims comprising the mining property: (1) Phoenix, (2) Silver Bow, (3) Red Hill, (4) Pope, and (5) Star. The original workings were located on the Phoenix claim, but the other claims have been developed since the early years of operations.

Reduction equipment on the property consists of a 4 by 65 ft. rotary furnace and a condensing system, and a retort.

The Knapp Corporation, together with C. W. Erickson, who is in charge of mining operations, have been conducting reportedly successful experiments with a concentrating device new in its application to the treatment of quicksilver ore. It is planned to handle up to 500 tons of fine low-grade ore a day. The completed plant as designed, includes

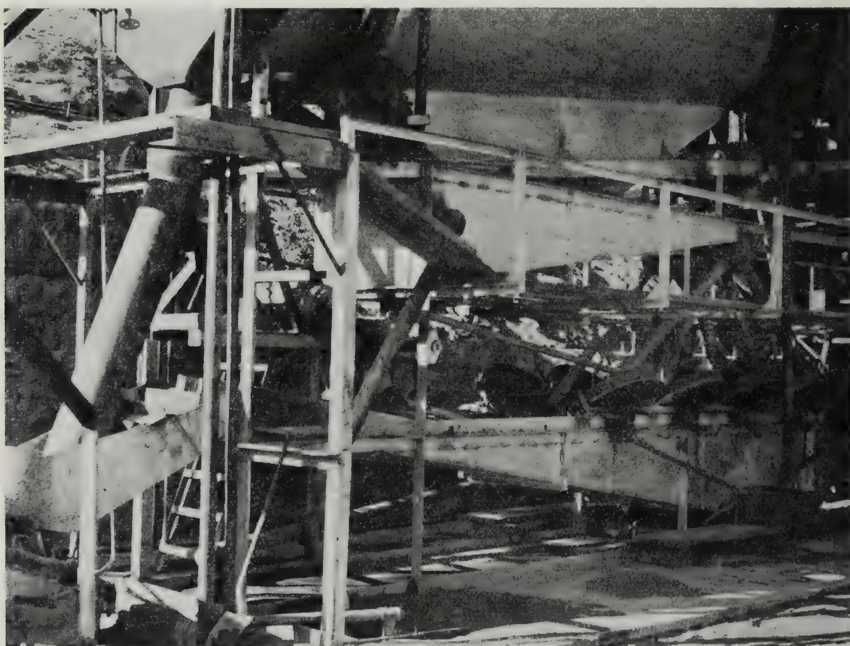

FIG. 8. Concentrator, Aetna Mine. The fine ore from the screen (top) is dewatered (just below screen) and passed over the rotating grooved disks (lower center). The concentrates are treated in a retort or rotary furnace. Reject material is mechanically raked from tank below the disks, and passed to the dump by conveyor belt.

a washing screen similar to those used on small dredges, a dewatering device, to remove water from the screen product, the concentrating unit, and a rake for removing the reject. The concentrating unit consists of 10 rotating disks mounted in two parallel rows of 5 disks to the row, each sloping inwardly over a tank at about 45° from the horizontal. The disks are approximately 30 inches in diameter, have a

cupped rim and a hard-rubber surface. In this surface are grooves cut in concentric curves from the edge of the disk to the center, coming to a focus at the lip of a hollow drive shaft. Each disk rotates at approximately 25 r.p.m., and is a complete concentrating unit by itself; the number of disks used to a plant depends upon the tonnage to be treated. The grade of concentrate can be regulated within certain limits by varying the tilt of the disk. The dewatered fines are fed to each revolving disk near the upper edge, and the rotary motion plus the agitation caused by the grooves, separates the light waste material from the heavier cinnabar. The waste is washed over the lower part of the rim of each disk into the tank below; this reject is disposed of by a mechanical rake. The cinnabar concentrates which are retained in the grooves gradually work upward to the center of each disk and through the hollow shaft to collecting buckets. Recovery of quicksilver from the concentrates is made with either the retort or the furnace.

Tests on the experimental plant have proved that very good recovery of cinnabar is obtainable. It is important to use clean water, as dirty water lowers the efficiency to some degree.

Bibliography: State Mineralogist Reports IV, p. 341; VI, pp. 72-73; XI, p. 72; XII, p. 362; XIII, p. 579; XIV, p. 284; XXV, p. 227. Bulletins 27, p. 72; 78, p. 77.

AETNA EXTENSION CLAIMS

(See under Other Counties and Mines, page 476.)

BELLA OAKS MINE (Formerly Bella Union)

Location. M. D. M., T. 7 N., R. 5 W., Sec. 20, about 1½ miles west of Oakville on the western side of Napa Valley.

Ownership. H. W. Gould and Company, San Francisco, California.

Production History. 1872-1873, 1876-?, 1916-1917, 1919-1920, 1929-1934.

There are two claims comprising the mining property of the Bella Oaks mine. First recorded production came from the Oakville in 1872 and 1873. In 1876 the Bella Union produced about 270 flasks. Operations were very sporadic to 1916, with some development work recorded for 1909 and 1910. In 1916, the mine was leased by the Rutherford Mining Company, and was operated intermittently through that and the following year. In 1919 the Rutherford Company resumed operations with H. W. Gould as general manager, and continued production through 1920. The mine was then idle for a period of eight years, until a lease was taken by the Bella Oaks Mining Company, headed by John Steckter. A 20-ton rotary furnace was installed that year, and put into operation by 1929. H. W. Gould and Company took over operations in 1931, and operated to the year 1934. Since that time there has been no recorded production from the property.

General Geology. The Bella Oaks mine is located in an area of serpentine intruded into Franciscan strata. The ore zone is in the serpentine, where crystalline and massive cinnabar, associated with pyrite in a quartz and calcite gangue, has been deposited in small veinlets.

Bibliography: State Mineralogist Reports XI, p. 364; XIV, p. 266; XXV, p. 228. Bulletins 27, p. 76; 78, p. 80.

CALISTOGA HOT SPRINGS

(See under OTHER COUNTIES AND MINES, page 476.)

CORONA MINE

Location. M. D. M., T. 10 N., R. 6 W., Secs. 32 and 33, about 9 miles southeast of Middletown, adjoining the Oat Hill mine which lies to the east.

Ownership. Vallejo Quicksilver Mining Company. James McCauley, of Vallejo, president.

Production History. 1895-1906, 1916.

The Corona mine is probably the latest discovered mine of any size in the Mayacmas district. Production began in 1895 and ended in 1904. During this period it was operated by the present owners, and considerable difficulty was encountered in treatment problems. A large amount of pyrite closely associated with the cinnabar made condensation of the mercury vapors difficult. A 50-ton Scott furnace was used for reduction of the ore, and this furnace is still standing on the property.

A small production was realized in 1916, by retorting ore taken out during a prospecting program; but since that time, the mine has been idle. The total recorded production to date is 4626 flasks.

General Geology. The Corona mine lies on the contact of serpentine and the same sandstone encountered at the Oat Hill mine. The ore occurs in a black chert between walls of serpentine and sandstone. Pyrite is an abundant and closely associated mineral with cinnabar in this deposit.

Bibliography: State Mineralogist Reports XIII, p. 579; XIV, p. 286; XXV, p. 229. Bulletins 27, p. 79; 78, p. 81.

IVANHOE MINE (Formerly Patten Claims and Mount St. Helena)

Location. M. D. M., T. 10 N., R. 6 W., S½ Sec. 34, between the Aetna and Oat Hill mines.

Ownership. Harry Patten, Aetna Springs, California.

Production History. 1931-1935, 1939.

This property remained undeveloped for many years, but in 1931, Harry Patten opened up the mine under the name of Mount St. Helena. He changed the name to Ivanhoe the following year, and reported small productions for ensuing years to 1936, and again in 1939.

General Geology. The ore in the form of cinnabar occurs in Franciscan sandstone similar to that at the Oat Hill mine.

JAMES CREEK PLACERS

Location. M. D. M., T. 10 N., R. 6 W., Secs. 34 and 35, situated along James Creek for several miles, in the vicinity of Aetna Springs.

Production History. 1915-1918, 1920-1925, 1927-1928, 1930, 1932, 1935-1936.

Cinnabar occurs as placer material in James Creek and, since 1915, various and sundry lessees have worked along the creek, concentrating the cinnabar and retorting the concentrates. The most diligent and persistent worker was Ah Lee of Aetna Springs who reported small productions nearly every year from 1920 to 1930. Production since the time of Ah Lee is credited to several lessees, among whom is E. J. Barnett, and Bert and Henry Wells.

General Geology. The placer deposits are credited to erosion of the extensive Oat Hill dumps by winter rains, by W. W. Bradley.[1] This is no doubt correct in part. Schuette[2] points out that probably the greater percentage of material is the product of erosion from an ancient orebody existent in past geologic times, above the land surface now forming the topography of the Oat Hill mine.

Bibliography: Calif. Min. Bur. Bull. 78, p. 82.

KNOXVILLE MINE (Formerly Excelsior, Redington, and Boston)

Location. M. D. M., T. 11 N., R. 4 W., Secs. 6 and 7. The Knoxville mine is located near the junction of Lake and Yolo Counties, in the extreme northern portion of Napa County. It is accessible by county road, about 21 miles southeast from Lower Lake.

Ownership. George E. Gamble, San Francisco, California.

Production History. 1862-1905, 1911-1912, 1915-1916, 1922, 1927-1936.

The Knoxville mine ranks fourth among the quicksilver mines of California, with a total recorded yield of 119,688 flasks to the close of 1936. Since the early 1900's, production from the Knoxville has been incidental compared to the great record made from 1862 to the turn of the century.

The mine was discovered accidentally while grading a road. The property was opened up in 1862, under the control of the X. L. C. R. Mining Company. During the first five years of operations, the production averaged about 1,800 flasks annually. The X. L. C. R. Company was reorganized as the Redington Quicksilver Company in 1867, and production immediately increased over 150 per cent. During the seventies, the Redington Company had a contract with the Comstock mines to supply them with 400 flasks a month. The mine has been owned by various interests since the Redington Company dissolved. The Boston Quicksilver Mining Company operated it for a number of years, and then sold to Fred Johnson, of Napa, in 1905. In 1918, Johnson sold the mine to the Berryessa Cattle Company (a subsidiary of the Associated Oil Company). The present owner, George E. Gamble, acquired the land in 1927 by purchase from the Berryessa Company. Productions then averaged about 700 flasks annually until the close of 1931. Production then began to decrease and finally ceased entirely in 1936.

General Geology. The mine is situated in a critical geological area, the detailed geology of which has not as yet been satisfactorily worked out. In general, the zone of ore deposition occurs on the contact between serpentine and Jurassic Knoxville sediments. This is the type locality for the Knoxville formation which is composed of shale, sandstone, and conglomerate. Northwest of the mine is a sheet of olivine basalt, the core of which forms a dike near a fault contact of serpentine and sediments. A heavy attrition gouge has been formed by fault movement and both the serpentine and shale are highly brecciated. Schuette[3] believes that part of the basalt sheet, exposed to the north-

[1] Bradley, W. W., op. cit., p. 82.

[2] Schuette, C. N., Occurrence of quicksilver orebodies: Trans. A. I. M. E., p. 422, 1931.

[3] Schuette, C. N., op. cit., p. 423.

west, originally extended over the present zone of mineralization. Mineral solutions then rose along the fault zone, but were trapped by the sheet of basalt and deposited cinnabar in the brecciated host rock below. Since that time erosion has worn away a great part of the orebody, leaving only the lowermost part.

Metacinnabar and cinnabar are closely associated with pyrite and marcasite in a black opaline gangue. The Knoxville district is the type locality for metacinnabar, which has probably been formed by acid surface waters and by sulphurous gases which redissolved some of the cinnabar, and which was then reprecipitated as the black mercuric sulphide.

Mine and Plant. The old mine workings have been discussed in literature that has been mentioned in the bibliography. Mr. Gamble did some development work in the mine, but the greater percentage of his production was from old dump material. Reduction equipment on the property consists of a 3-by 40-ft., 30-ton rotary furnace, a tile condensing unit, and a D retort.

Bibliography: State Mineralogist Reports I, p. 27; IV, p. 339; VI, p. 72; XI, p. 69; XII, p. 363; XIII, p. 599; XIV, p. 287; XXV, p. 230. Bulletins, 27, p. 76; 78, p. 82.

LA JOYA MINE

Location. M. D. M., T. 7 N., R. 6 W., Sec. 24, about 6 miles by county road west of Oakville and about 4 miles west of the Bella Oaks mine.

Ownership. H. W. Gould and Company, San Francisco, California.

Production History. 1898, 1915-1918, 1928-1934, 1936-—.

The La Joya mine was first opened up by the Standard Quicksilver Mining Company (then operating the Mirabel mine) in 1898. Production was not continued after 1898, and the mine remained idle until 1915. That year, James Rennie purchased the property. It was taken under lease and bond by the West Coast Investment Company the following year. Production continued through 1917 and 1918; but in 1919 the option was given up, and the property reverted to Rennie. A period of idleness followed which was not broken until 1928, when the Acme Mining and Milling Company reopened the mine. This new company operated until 1931, at which time the property was taken under lease by the Lucky Strike Company. This company made regular, though small, annual productions until 1934. They experimented with butane gas fuel and although the results were apparently satisfactory, its use was discontinued with the termination of the lease of the company, late in 1934. R. A. Hannon leased the mine in 1935, and in 1936 the La Joya Quicksilver Mining Company became the lessee. In 1938 and 1939 a few flasks were obtained by lessees using a rotary furnace.

General Geology. The country rocks surrounding the La Joya mine are serpentine and Franciscan sandstone. Mineralization has taken place in a zone of highly altered serpentine which strikes northwest and dips at a flat angle to the southwest. Cinnabar is found in the serpentine generally in crystalline form, associated with pyrite and native quicksilver in a chalcedonic gangue.

Mine and Plant. The mine is developed by tunnels and raises, and is completely described in the literature given under references.

The Acme Mining and Milling Company installed a new plant in 1928. It consists of a 3-by 40-ft. Gould rotary furnace and a condensing unit using cast iron pipes.

Bibliography: State Mineralogist Report XXV, p. 231. Bulletins 27, p. 80; 78, p. 84.

MANHATTAN MINE (Formerly Lake mine)

Location. M. D. M., T. 11 N., R. 4 W., NW$\frac{1}{4}$ Sec. 6; T. 11 N., R. 5 W., N$\frac{1}{2}$ Sec. 1; T. 12 N., R. 5 W., SW$\frac{1}{2}$ Sec. 36. This mine adjoins the Knoxville mine on the west, and is about 20 miles southeast of Lower Lake.

Ownership. Manhattan Quicksilver Mines Company. R. B. Knox, president. Last leased to Charles Wilson and W. N. Hickox of Monticello.

Production History. 1862-1877, 1884-?-1893, 1895-1905, 1916, 1927, 1938-—.

Quicksilver was first noted on this property about the time the Knoxville mine began operations. The Manhattan operated in conjunction with the Knoxville for several years, reducing its ore in the Knoxville furnace. The mine was idle from 1877 to 1884, at which time it is reported to have been reopened, although production during the next few years is not definite. A Knox-Osborne fine-ore furnace was installed in the eighties or nineties, and this has never been replaced by a modern plant. The present company has owned the mine for many years, having acquired it prior to 1900. Since 1905, only a very few flasks of quicksilver have been recovered.

General Geology. The geology of this mine greatly resembles that of the Knoxville as the orebody is a northwestern extension of the Knoxville orebody.

Bibliography: State Mineralogist Reports I, p. 27; V, p. 95; VIII, p. 412; XI, p. 71; XII, p. 363; XIII, p. 598; XIV, p. 288; XXV, p. 235. Bulletins 27, p. 81; 78, p. 86.

MOUNTAIN MINE

(See under Other Counties and Mines, page 476.)

NORTHERN LIGHT PROSPECT

(See under Other Counties and Mines, page 476.)

OAT HILL MINE (Formerly Napa Consolidated mine)

Location. M. D. M., T. 10 N., R. 6 W., Secs. 27, 28, 33, and 34. The Oat Hill mine lies about 9 miles southeast of Middletown, on the Livermore estate. It is about half a mile east of the Corona mine, and 2 miles northwest of the Aetna mine.

Ownership. Norman Livermore, owner; H. W. Gould, lessee.

Production History. 1876-1910, 1913-1920, 1923, 1927-—.

This mine, the third largest quicksilver mine in the State, had a long and continuous production record in early years. It was opened up in 1876 by the Napa Consolidated Company, and after operating the mine for 24 years, the mine closed down in 1910, as the ore had

dropped to an uneconomical grade at the existing price. Through 1913 and succeeding years to 1920, the mine and dumps were worked by various lessees. R. P. Newcomb operated here for a short time, and also E. J. Sittig. In 1918, Murray Innes took a lease on the underground workings and did some development work. He started producing in 1920, but closed down in the following year because of the low price of quicksilver. Innes produced a few more flasks of quicksilver in 1923, but he then abandoned the property and it remained idle until 1927, at which time a ten-year lease on the property was taken by H. W. Gould, who produced a few flasks by retorts in 1927 and in the two following years. In 1930, Gould sub-leased to the Acme Mining and Milling Company, which operated until 1933, using a newly installed Gould rotary furnace. R. A. Hanan and Company operated the mine under lease until 1937. John Wanzel operated under lease during 1938. Gould and Company are now operating the property.

General Geology. The rocks in which cinnabar has been deposited at the Oat Hill mine consist entirely of Franciscan sandstone. To the north of the mine workings, about half a mile away at the top of the hill, is a basalt flow, remnants of which are scattered over the hillside. There are eight roughly parallel major fractures in the sandstone, which have a general NE.-SW. strike. Mineralization is directly associated with these fractures, with cinnabar occurring both as a fracture filling and as an impregnation of the country rock on both the hangingwalls and footwalls. Schuette [1] believes that the basalt flow originally extended over the present mineralized zones, and that solutions rose through planes of weakness developed in the sandstone by the extrusion of the basalt. When the mineral solutions reached the basalt, they were trapped and cinnabar was deposited in large, highgrade orebodies. Mining is now done in the remnants of these old orebodies, as erosion has apparently carried away a great percentage of the ore. A possible proof of this theory is found in James Creek, below the mine workings, where placer mining for cinnabar has been carried on for a number of years.

The Franciscan sandstone is light gray in color, and is quite soft and porous. Numerous clay gouges on both the hanging and foot walls of fracture zones indicate a considerable amount of faulting in the area. The grade of ore depends largely upon the porosity of the receptacle rock, as well as in the size and shape of the gouge which often form traps for local enrichment.

Mine and Plant. An estimated 20 miles of underground workings exist at the Oat Hill mine, nearly all of which are either caved or inaccessible at present.

The mine is now developed by an adit level which extends about 500 ft. into the hillside, and strikes an orebody at this point. There are several known stopes in this mine which were lost by former operators because they attempted to hold them open with square sets. The ground, however, is much too heavy for this method of mining. The developed orebody has been mined by square sets about 20 ft. high, and has been blocked out to a width of approximately 70 ft. The ground

[1] Schuette, C. N., op. cit., p. 421.

is so soft that any drilling which is necessary is accomplished by machine-operated augers.

Ore from the mine is hand-trammed to the portal of the main adit level, and dumped down a wooden chute about 50 ft. to a bin. From here it is hand trammed about 100 ft. along the side of the hill, and dumped into a second bin. Trucks are loaded at this point, and transport the ore about a mile by road to the plant. Here the ore enters a primary ore bin over a 2-in. grizzly, and the oversize is crushed in a 10-

FIG. 9. Condenser pipes, Oat Hill Mine, Napa County. Cooling is effected both by exposure to air and by the use of water which flows down the outside of the pipes. The condensers are in the process of being washed down by the use of a water spray.

by 12-in. jaw crusher to about 1½-in. size. A shaker feeder feeds the fine ore to a 4½- by 60-ft. Gould rotary furnace, with a rated capacity of 60 tons per day. About 40 tons of ore per day are treated in this manner at present. The fuel consumption for the furnace averages about 8.5 gal. of crude oil per ton of ore treated.

Furnace gases pass to a modern condensing unit consisting of 2 banks of stainless steel condensing pipes with 6 pipes per bank. The pipes are water cooled on the outside, to insure rapid condensation. Three redwood settling tanks and 2 tile pipes to a redwood stack, complete the plant equipment. Soot collected from the condensing pipes is thoroughly hoed with unslaked lime, and the soot is then returned to the feed end of the furnace.

Bibliography: State Mineralogist Report I, p. 27; IV, p. 338; V, p. 96; VI, p. 72; VIII, p. 413; XI, p. 65; XII, p. 364; XIII, p. 598; XIV, p. 289; XXV, p. 235. Bulletins 27, p. 89; 78, p. 88.

OAT HILL EXTENSION

Location. M. D. M., T. 10 N., R. 6 W., Sec. 34, adjoining the Oat Hill mine to the south.

Ownership. Zack Anderson.

Production History. 1932-1934, 1936- —.

Zack Anderson began working on a small claim here in 1932, and has operated off and on to the present time, producing a total of about 300 flasks to 1939.

General Geology. See Oat Hill mine.

Mine and Plant. Anderson is operating the mine through a small adit extending into the hillside below the Oat Hill furnace.

The plant consists of a concentrating unit including a jaw crusher, a set of rolls, and a Deister-Overstrom shaking table. Concentrates are treated in a D retort.

PALISADES SILVER MINE

(See under Other Counties and Mines, page 476.)

PHILADELPHIA CLAIMS

(See under Other Counties and Mines, page 476.)

Fig. 10. Oat Hill Extension Mine and concentration plant, Napa County. Mine portal at lower left; crusher at top of incline hoist; shaking table under shed at center.

SUMMIT MINE

Location. M. D. M., T. 7 N., R. 5 W., Sec. 19, about 3 miles west of Oakville, and a mile southeast of the La Joya mine.

Ownership. Last reported owner (1918), J. Scheerer, San Francisco.

Production History. Early 1870's. In 1916, some development work was done. There has been no operation since.

Bibliography: State Mineralogist Reports XII, p. 365; XIII, p. 599; XIV, p. 291. Bulletins 27, p. 92; 78, p. 90.

TOYON MINE (Formerly Granada; also known as Switzer mine)

Location. M. D. M., T. 10 N., R. 6 W., Sec. 34, about a quarter of a mile east of the Oat Hill mine.

Ownership. ——— Switzer, owner; leased by Frank Adams.

Production History. 1933-1935, 1939.

This mine was originally opened by the Granada Quicksilver Mining Company in 1929, but no production under this company has been recorded. In 1933, Frank Adams leased the property from Switzer, and produced in small amounts until the close of 1935. He again reported a few flasks produced during 1939.

General Geology. The ore is reportedly found as cinnabar under a black talc seam hanging wall.

Bibliography: State Mineralogist Report XXV, p. 230.

TWIN PEAKS MINE

Location. M. D. M., T. 9 N., R. 6 W., Sec. 4; and T. 10 N., R. 6 W., Sec. 33, adjoining the Corona mine on the southwest, and about 9 miles northeast of Calistoga.

Ownership. Twin Peaks Mining Company; care of L. D. Fay, Oakland, California.

Production History. 1904-1906, 1915-1918.

Production at this mine began in 1904, and continued for a 2-year period at the end of which time a lens of ore was mined out and, as no development work had been done, the mine was closed down. The Twin Peaks Mining Co., owners, reopened the mine in 1915, and operated to the close of 1918. There has been no activity of note on the property since that time.

General Geology. The ore is said to occur at the contact of serpentine and Franciscan sandstone.

Bibliography: State Mineralogist Reports XIV, p. 291; XXV, p. 238; Bulletins 27, p. 92; 78, p. 91.

WHITNEY MINE

Location. M. D. M., T. 10 N., R. 5 W., Sec. 21, in Snell Valley 10 miles southeast of Middletown.

Ownership. Last reported owner (1918), G. B. Whitney, Calistoga.

Production History. It is recorded that a few flasks of quicksilver were produced using a retort.

General Geology. Cinnabar occurs in a schistose sandstone, the country rock being sandstone and serpentine.

Bibliography: State Mineralogist Report XIV, p. 292. Bulletin 78, p. 91.

NEVADA COUNTY

(See under OTHER COUNTIES AND MINES, page 476.)

ORANGE COUNTY

RED HILL MINE (Also known as Tustin mine)

Location. S. B. M.[1], T. 5 S., R. 9 W., Sec. 14, at Tustin, about 5 miles east of the city of Santa Ana.

Ownership. F. B. Browning, Tustin, California.

Production History. 1927-1929, 1932-1933, 1939.

Although the occurrence of cinnabar was known at this locality as early as 1892, the mine was first opened up by F. B. Browning, in 1927, and was a steady, although small, producer to the close of 1929. The ore was retorted. There has been no reported activity on the property since that time, except for a very few flasks produced in 1932-'33 and during 1939.

General Geology. The ore minerals, cinnabar and native quicksilver, are associated with small veins of barite in Tertiary sandstone country rock.

Bibliography: State Mineralogist Reports XI, p. 118; XV, p. 516; XXVI, p. 54; Chap. rep. bien. period, 1915-1916, p. 56. Bulletins 67, p. 35; 78, p. 92.

SAN BENITO COUNTY

San Benito County ranks second in quicksilver production among the counties in California. The total recorded production in this county, to the close of 1938, is 386,124 flasks, of which the New Idria mine is credited with approximately 365,000[2] flasks.

Bradley[3] states:

> "There are three quicksilver districts in the county, all situated in the Diablo Range, which traverses the eastern part of the county in a northwest-southeast direction. The Stayton district is at the northern end, at the junction of San Benito, Santa Clara, and Merced counties. The New Idria district is in the southeast corner of San Benito County; and the third district, in which are the old Cerro Bonito and Bradford mines, is situated between the other two."

The New Idria district has, of course, been the principal producer. Besides the New Idria mine, there are several small mines in the near vicinity which have been made small, but persistent, productions. The Central San Benito district has been idle for many years, and is now abandoned. The Stayton district, containing the Stayton mine and a few other smaller mines, was fairly active at one time prior to 1880; but since that time it has produced only a small amount.

ALPINE MINE (Formerly Esmeralda)

Location. M. D. M., T. 18 S., R. 11 E., Secs. 13 and 14, about 6 miles from Hernandez and 40 miles by road from Coalinga in the New Idria district.

Ownership. Harry B. Leonard, Hollister.

Production History. 1912-1914, 1916-1917, 1928, 1932-1936.

This mine, originally consisting of 32 claims, was discovered by Silvester Tirado who sold it to the Alpine Quicksilver Mining Company in 1910. First production was made in 1912, using "D" and

[1] S. B. M., San Bernardino Meridian.
[2] Figures are taken from those on record at the Calif. State Div. of Mines.
[3] Bradley, W. W., Quicksilver resources of California: Calif. State Min. Bur. Bull. 78, p. 93, 1918.

pipe retorts to treat the ore. During 1915, a 20-ton Scott furnace was installed. It was operated for a few months in 1916, and again for a short time in 1917, after which date the plant and mine were shut down and remained idle for many years. In 1920, a mortgage was foreclosed on the property, but not until 1928 was there any activity. At this time a few flasks were produced from pipe retorts. In 1932, H. B. Leonard, a former manager of the mine, reported a small production and there was activity on the property every year from that time through 1936.

General Geology. This mine is located in the great mass of serpentine which spreads southward from New Idria. Along a fault in the serpentine, cinnabar has been deposited with a chalcedonic gangue in the fracture zone. At a depth of 190 ft. the country rock seems less silicified than in the surface outcrops.

Bibliography: State Mineralogist Reports XV, p. 649; XXII, p. 240. Bulletin 78, p. 96.

AURORA MINE (Formerly Morning Star)

Includes the Monterey mine (formerly Boston).

Location. M. D. M., T. 18 S., R. 12 E., Sec. 5, about one mile south of the New Idria mine.

Ownership. Aurora Mines, Paul E. Wingert, Idria, California.

Production History. 1853, 1915, 1917, 1930-1939.

This property is reported to have been discovered in 1853, but only intermittent work was carried on until 1911. At this time a rotary kiln was installed by the Esmeralda Quicksilver Mining Company. Because of mechanical difficulties this plant was not operated. By 1915, the plant had been improved and repaired, and operations proceeded for a few weeks when severe winter storms cut off the fuel oil supply, forcing another shut down. The Esmeralda Company, meanwhile, was developing another property known as the Monterey Group, about 4 miles southwest of the Aurora. Except for a short period in 1917, both mines were shut down and remained idle for many years. In 1930, activities at the mine again resumed. During the years 1930-1936, several different operators reported production. In 1930, H. Carhartt operated; in 1931, John Turpen reported a small production; during 1932, W. S. Brainard operated; and in 1933, the B. and L. Development Company reported an all-time high in number of flasks produced. During 1934 and 1935, Peter Bual produced a small amount; and in 1936, the San Benito Mining Company took over the property and also produced a fair amount. Paul Wingert operated the property during 1938. J. Vallejo reported a few flasks produced during 1939.

General Geology. The Aurora mine is not on an extension of the New Idria ore zone, in spite of its proximity to the latter. It is situated within the serpentine area very near the contact of serpentine and Franciscan sandstone, and the deposit is said to be quite shallow with no great extent horizontally. Cinnabar occurs in veins of dark green to white chalcedonic material. The strike of the croppings is approximately N. 15° W.

Bibliography: State Mineralogist Reports XV, p. 651; XXII, p. 241. Bulletins 27, pp. 131, 137, 138; 78, p. 99.

BITTER WATER MINE (Also known as Bitter Water Creek)

Location. M. D. M., T. 15 S., R. 9 E., Sec. 25, on Bitter Water Creek about 2 miles southwest of Llanada.

Ownership. H. V. Underwood and E. A. Matthews, Hollister, California.

Production History. The only record of production from this property is for 1932, and again during 1938 when a few flasks of quicksilver were retorted.

BONANZA GROUP

(See under Other Counties and Mines, page 476.)

BUTTS MINE

Location. M. D. M., T. 16 S., R. 8 E., Sec. 4, about 21 miles south of Tres Pinos, in the Central San Benito district.

Ownership. Last reported owner (1918) William Butts, Pine Rock, California.

Production History. 1915, 1918-1919.

Previous to 1900, some work was done on this property, but there is no record of any production. However, in 1915, Mr. William Butts leased the property to George Kline who produced a small amount using a "D" retort, while striving to find an orebody. During 1918 and 1919, Butts operated the property himself, recording only a small production. The property has been abandoned since that time.

General Geology. The country rocks are sandstones and shales. The ore minerals are cinnabar and metacinnabar in a calcite cement of a sandstone and chert breccia.

Bibliography: State Mineralogist Report XV, p. 653. Bulletins 27, p. 133; 78, p. 101.

CANNON MINE

(See under Other Counties and Mines, page 476.)

CERRO BONITO MINE

Location. M. D. M., T 16 S., R. 10 E., Sec. 31, about 30 miles southeast of Tres Pinos and 2 miles south of Llanada, in the Central San Benito district.

Ownership. Cerro Bonito Quicksilver Mining Company; Thomas Flint, President, Hollister, California.

Production History. 1874-1876, 1902.

This mine is one of the oldest mines operated in the region, but it never became a very large producer. Previous to 1874 and through 1876, the total production was reported as over 800 flasks. The property remained idle from 1876 until 1902, when it was taken over by the Cerro Bonito Quicksilver Mining Company. This company did a little development work and rebuilt the furnace. Since that time, however, the property has remained idle and is now abandoned.

General Geology. The country rock of the region is a metamorphosed sandstone which has been highly brecciated, and is covered by a basalt flow in some places. The ore consists of cinnabar on the fracture faces of the brecciated sandstone.

Bibliography: State Mineralogist Report XXII, p. 241. Bulletin 78, p. 102.

CERRO GORDO or BRADFORD MINE

Location. M. D. M., T. 15 S., R. 8 E., Secs. 3, 4, and 9, on Tres Pinos Creek about 5 miles east of Emmett, and 18 miles from Tres Pinos.

Ownership. Last reported operator (1918), J. F. Latham, lessee, Los Gatos, California.

Production History. Cinnabar was discovered here in 1859 as an incident to the construction of a road from Tres Pinos to the New Idria mines. No definite orebody was found, but serpentine carried some cinnabar throughout. It is reported that some quicksilver was produced in earlier years, but the property has been idle for over 20 years.

Bibliography: State Mineralogist Report XV, p. 653. Bulletins 27, pp. 131-133; 78, p. 101.

DON JUAN and DON MIGUEL MINES

(See under OTHER COUNTIES AND MINES, page 476.)

FLINT GROUP (Andy Johnson, Fourth of July, Clear Creek)

Location. M. D. M., T. 18 S., R. 11 E., Secs. 2, 11, 12, and 13, and T. 18 S., R. 12 E., Sec. 18, on Clear Creek about 5 miles from Hernandez, in the New Idria district.

Ownership. W. C. Webster, Hernandez, California.

Production History. Pre-1880 (?), 1916-1917, 1933-1934, 1936, 1939. These three properties were all operated at one time or another prior to 1880, but definite data for this period are not available. At the close of 1916 and through 1917, lessees operated the properties, retorting what rich ore was easily available. At the close of 1917, the mines were practically abandoned. However, in 1933, the old Clear Creek property was reopened by W. C. Webster, who reported a slight production in a small furnace that year and the one following. Again in 1936, W. C. Webster reported a small production. Albert Funk, San Benito, Cal., reported a small production during 1939 from the Clear Creek property.

General Geology. The mines are located along a series of prominent silicified serpentine outcrops which strike northwest from the Hernandez mine. This serpentine is part of the large mass which spreads southward from New Idria.

Bibliography: State Mineralogist Reports XV, p. 651; XXII, p. 241. Bulletins 27, p. 131; 78, p. 98.

FLORENCE MAC MINE

Location. M. D. M., T. 18 S., R. 12 E., Sec. 32, about 10 miles from Hernandez on the upper San Benito River, and one mile east of the Hollister-Coalinga highway.

Ownership. L. H. Burns, King City; Arthur Hoag, Hollister.

Production History. 1915, 1925, 1927, 1930-1933, 1935- —.

First activities reported on this property were in 1904, and following years. In 1915, a 12-pipe retort was installed, but difficulty in condensing was encountered and the mine was closed down. It remained idle until 1924, when C. P. Smith did some assessment work, and then retorted a little ore during the following year. Again in 1927,

a small production was reported; and in 1930, Joe Stokes started work which he carried on through 1933. During recent years, R. Orozco, et al., Rex Smith, Mgr., operated the property and produced a fair amount of quicksilver.

General Geology. The mine lies just south of the large serpentine belt which characterizes the New Idria district. The country rock consists entirely of sedimentary rocks. The ore is cinnabar, associated with pyrite, in a stratum of black clay shale.

Bibliography: State Mineralogist Reports XV, p. 665; XXII, p. 242. Bulletin 78, p. 103.

HERNANDEZ MINE (Also known as Picachos, Los Picachos, and Ramirez)

Location. M. D. M., T. 18 S., R. 12 E., Secs. 19 and 20, about 2 miles north of the Florence Mac mine and 12 miles from the town of Hernandez, in the New Idria district.

Production History. 1902, 1904-1906, 1913-1916, 1918.

Records for this mine are not available for early production, but as far as can be learned, not much quicksilver was produced prior to

FIG. 11. Los Picachos or Hernandez Mine, San Benito County. The bold outcrops are altered serpentine, the so-called "quicksilver rock"; the surrounding hills are serpentine.

1900. In 1902, and from 1904 through 1906, the property was operated under the name of Ramirez Consolidated, and a small production was recorded for the three-year period. In 1913, the mine was again operated, this time by the Hernandez Quicksilver Mining Company. At the close of 1916, the mine was shut down. A small production was reported by C. P. Smith in 1918. The property has been inoperative

since that date with the exception of recent prospecting work in 1938 and 1939.

General Geology. The country rock is the serpentine mass extending southward from New Idria. Striking northwest through the property is a mineralized zone about half a mile wide. The zone is characterized by outcrops of siliceous rocks, which rise prominently above

FIG. 12. The New Idria Mine and plant, San Benito County. The mine workings are in the hill in the right background; the active open-pit operations are up the hill to the right; the portal of the 1000-foot level enters the hill behind the plant. The characteristic rugged topography is well illustrated.

softer serpentine. The ore is cinnabar associated with pyrite, and occurs along fault fissures and fracture joints in the silicified material.

Bibliography: State Mineralogist Reports XV, p. 658; XXII, p. 242. Bulletins 27, p. 145; 78, p. 105.

LONE STAR MINE

(See under OTHER COUNTIES AND MINES, page 476.)

NEW IDRIA QUICKSILVER MINING CO. (New Idria and San Carlos mines)

Location. M. D. M., T. 17 S., R. 12 E. (New Idria), Secs. 28, 29, 32, 33, 34, and 35; and T. 18 S., R. 12 E. (San Carlos), Secs. 3 and 4. The mining property includes the Idria, West Idria, Sulphur Spring, Molino, and San Carlos groups of claims, covering a total of 240 acres of patented mining claims, and 4200 additional acres of patented land. The mine is located 67 miles by county road southeast of Hollister, and 55 miles by county road southwest of Mendota. It lies at an elevation of 2500 to 5200 ft. on the northeastern slope of the Diablo Range, which traverses San Benito County in a northwest-southeast direction.

Ownership and Staff. New Idria Quicksilver Mining Company, 10 Penthouse, Mills Building, San Francisco, California. Henry W. Gould, general manager; C. Hyde Lewis, general superintendent.

Production History. 1854-1920, 1923-—.

The first recorded production was in 1854, and except for a period of two years from 1921 to 1923, the mine has been in continuous operation. Early production figures are indefinite; but by 1866, the mine had risen to such size that it was in a position to compete with the New Almaden mine. The recorded figures show productions of 11,493 flasks in 1867; 12,180 flasks in 1868; and 10,315 flasks in 1869. From this date to the close of 1894, the annual production from the New Idria slowly decreased. In fact, the production for the year 1891 amounted to only 792 flasks. The property was purchased from the New Idria Mining Company by the New Idria Quicksilver Mining Company, with central offices in Boston, Massachusetts, in 1935. The production began to rise immediately. From 150 to 250 men were employed at various times, and the average annual production amounted to 7000 or 8000 flasks up to the year 1915. With the start of the World War, there were only two California mines which could adequately meet the tremendous demand for quicksilver. The ore reserves of the New Almaden were nearly depleted, and thus the New Idria was left as the principal producer. With H. W. Gould as general superintendent, the management hired from 300 to 400 men; and, with about 400 soldiers guarding the property, it responded to the call of the Government by producing 10,835 flasks in 1916; 11,000 flasks in 1917; and 10,700 flasks in 1918. Most of this metal was produced from ore which was taken from old dumps and open cuts on the original outcrop. It was reduced in two 88-ton coarse-ore furnaces of a design developed by B. M. Newcomb, general manager of the company, and in a Scott fine-ore furnace of 60 tons capacity. However, in 1916, Gould introduced the first successful adaptation of the rotary kiln for the reduction of quicksilver ores in this country. After the success of the first experimental furnace, Gould installed four furnaces of somewhat larger size and capacity, and all four were then operated to the close of the war period. In the summer of 1920, a fire destroyed part of the plant, and the operators were forced to close the mine. In 1922, the property was purchased by the New Idria Quicksilver Mines, with W. R. Moorehead as general manager. Rehabilitation occupied the new company's time until 1923, when the mine was again placed on the producing list. In 1927, Moorehead commenced putting into effect a development program which consisted of stripping about 3,000,000 tons of overburden in order to uncover, and make available for open-cut mining, all the ore from the original outcrop to the 300 level. By 1931, about 1,500,000 tons of waste had been stripped when the world depression knocked the bottom out of the quicksilver market. The mine was forced into a period of inactivity, and the only production for the following four years was from dump material, and from excavations under the old Scott and Idria furnaces. In 1936, the present owners took control, and operations in the mine began anew. The rate of production steadily increased, and averaged better than 300 flasks a month during 1938.

Geology. The various claims comprising the New Idria mine are in a faulted and distorted zone of Franciscan sandstones and shales.

To the south is a large intruded mass of serpentine which contacts the Franciscan strata about a mile south of the town of Idria, and to the north is a series of Cretaceous and Eocene sediments consisting of Panoche sandstones and clay shales, Moreno shales and concretionary sandstones, Cantua shales and sandstones, Tejon beds, and other formations. These beds all dip 30°-60° N., and strike about N. 60° W.[1]

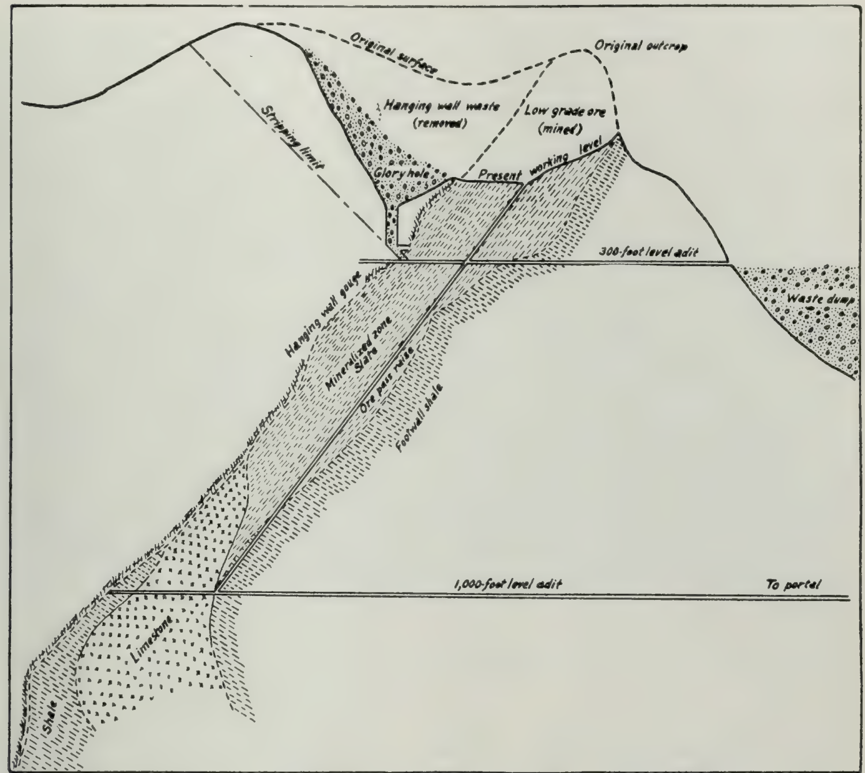

FIG. 13. Generalized cross section of the New Idria orebody. *(After W. R. Moorehead, U. S. Bur. Mines Inf. Circ. 6462.)*

The lowermost, or Panoche formation, makes what Lake[2] considers to be a fault contact with the Franciscan strata at a point about 1000 feet up the hill from the portal of the No. 10 tunnel. The Franciscan strata consist of massive beds of greenish brown sandstone interbedded with a layer of flinty black slate (so termed by Lake) and a layer of highly contorted black shale.

The structure of the mineralized area is extremely complicated because of the degree of contortion found in the Franciscan strata. However, Lake has mapped two large thrust faults which are roughly parallel, strike about N. 60° W., and dip 60° S. According to Schuette,[3] the movement along these faults has formed hangingwalls

[1] Anderson, R. and Pack, R. W., Geology and oil resources of the west border of the San Joaquin Valley, north of Coalinga: U. S. G. S. Bull. 603. 1915.
[2] Lake, M. C., Geologic maps of the New Idria mine at the mine office, Idria, California, 1929.
[3] Schuette, C. N., Occurrence of quicksilver orebodies: Trans. A. I. M. E., p. 418, 1931.

and footwalls of attrition gouge. He points out, from the work of E. B. Dane, Jr.,[1] that the movement on the south side has taken place along the contact of serpentine and Franciscan strata. Lake, on the other hand, has mapped this same fault between a large area of greenish sandstone and the black flinty slate previously mentioned. As very little development has been carried beyond the hangingwall, some doubt still remains as to the proximity of the serpentine mass to the ore zone at depth. The movement along the fault zone is attributed to two periods by Schuette.[2] During the first period, the movement was probably vertical, with a possibility of both large faults being thrust faults (as mapped by Lake) and with the south side being the upthrust side in each case. The second period seems to show a horizontal movement, with the northern strata moving west in respect to the southern strata. This movement is the one which formed the hangingwall gouge. The attitude of the Franciscan strata indicates clearly a condition of overturned beds existing in the region. At the higher elevations near the present workings, the beds have a general south dip, in contrast to the adjoining Panoche formation. At the lower elevations, southeast of the mine, the surface geology indicates both vertical beds and very steep dips to the north.

The New Idria orebody is more or less sickle-shaped with the horns curving north; it varies in width from 120 to 230 ft., and in length from 800 to 1200 ft. According to Schuette,[2] an igneous dike has intruded the Franciscan strata along a rift caused by movement on the fault. This dike, the composing material of which has been altered almost beyond recognition, now forms the famous New Hope vein and the Elvan streak first described by Becker[3] in 1888. The New Hope vein is a fissure in the hangingwall, striking about N. 60° W., and limited in extent to the northwest by the gouge of the hangingwall. The Elvan streak, which is offset from the New Hope by a matter of 200 or 300 ft. to the west, strikes about N. 30° W. across the orebody and into the footwall. The southeastern extent is limited by the gouge of the hangingwall. Thus it appears that these two fissure fillings belong to the same intrusion, and have been displaced by a horizontal movement. Since there is no evidence of the hangingwall gouge being displaced, it is safe to consider that it was formed during the period of horizontal movement.

Mineralization probably followed the intrusion of the dike into the Franciscan strata which, in their shattered condition, provided excellent receptacle rocks. Ore occurrences throughout the orebody are rather irregular, and are generally found as a complicated series of interlacing veins and cross-veins of cinnabar, and as impregnations of the mineral into the country rock. Throughout the flinty black slate the cinnabar occurs along fracture faces and as fissure fillings. There has been very little, if any, dissemination of the mineral through this rock. However, the sandstone series of the mineralized zone has been well impregnated with cinnabar, which generally occurs in fine crystalline form. The New Hope vein is said to have carried meta-

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[1] Dane, E. B., Jr., Geologist of the New Idria Company in 1930.

[2] Schuette, C. N., op. cit., p. 419.

[3] Becker, G. F., Geology of the quicksilver deposits of the Pacific Slope: U. S. G. S. Monograph 13, p. 302, 1888.

cinnabar in large quantities; but the main quicksilver mineral of the present workings is cinnabar associated with a small amount of pyrite in a gangue of quartz, calcite, and gypsum.

The San Carlos mine, located about 2 miles southeast of the town of Idria, is owned by the New Idria Quicksilver Company, but has not been recently operated although development work is in progress

Fig. 14. Open pit and glory hole, upper workings of the New Idria Mine, San Benito County. Ore mined from the pit is trucked to the glory hole where it passes to the level below, and over a sorting belt. It is then passed down a chute to the main haulage level and transported to the furnace plant by aerial tramway.

(1939). Mr. C. H. Lewis, general superintendent at the mine, believes that the main future ore reserves for the entire mine probably lie in the San Carlos property. The mine is on an extension of the Franciscan strata and in the same fault zone, noted at the New Idria mine, but the ore zone on the former property is much closer to the intruded serpentine mass. The ore occurs as veins of cinnabar, and as impregnation of a blocky white sandstone which is somewhat harder than that found at New Idria. A serpentine dike cuts through the Franciscan strata,[1] and it is possible that the mineralizing solutions ascended along this dike and permeated the overlying beds.

Mine and Plant. The nature of the topography at New Idria, with the outcrop of the orebody near the top of a steep hillside, permits entry to the mine by a series of adits starting with the 200-ft. level and including 300-, 400-, 500-, 700-, and 1000-ft. levels. Workings below the 1000-ft. level were accessible through a three-compartment winze from this level to a depth of 1400 ft. below the highest point on the outcrop. The upper workings are developed by a series of drifts, cross-

[1] Bradley, W. W., Quicksilver resources of California: Calif. State Bur. Mines Bull. 78, p. 115, 1918.

cuts, and raises which total about 20 miles in length. However, at the present time there is no mining activity below the 500-ft. level.

The main mine workings are in the bottom of a large open-cut, situated above the 200-ft. level. Here, selective glory-hole mining is used; following streaks of ore in deep trenches. The ground is broken by powder and sledge hammers, and the larger pieces of waste are discarded before the ore is dumped down a raise to the 300-ft. level. On this level the ore passes over a 2-ft. sorting belt which is well illuminated by electric lamps, and two sorters discard all material which does not show any cinnabar. The sorted ore passes on down to the 500-ft. level by gravity, and the reject is trammed from a small bin to old empty stopes. The 500-ft. tunnel-level is now the main haulage level, and all the ore mined is transported to the portals of this tunnel by train hauled by means of a small storage battery locomotive. The underground mining program consists of extracting fill material from old stopes above the 400-ft. level, using the square set method of mining. The ore thus extracted is passed through raises to the 500 level without sorting.

From the northern rim of the glory-hole to the level of the No. 3 tunnel is a large dump of low grade ore which was rejected from the glory-hole by former operators. Until a few months ago the present owners were working this dump material by power-shoveling it into trucks, and transporting it over a steep and tortuous road for about 1½ miles to the plant.

Because this ore, in order to be treated economically in the furnace, must run over 5 lb. of quicksilver per ton, an interesting method for treating it was recently put into effect at the portal of the No. 3 tunnel.

This method involves screening, jigging, and sluicing over riffles. The ore is power-shoveled into trucks and dumped over 6-in. grizzly which is set up over a pit. The minus 6-in. material falls into a small bin, from where it is fed onto a 24-in. conveyor belt at the same time that the coarse waste is rejected. The conveyor belt elevates the ore 24 ft. to a two-deck vibrating screen with 2-in. openings in the upper deck and five-eighths in. openings in the lower deck. Oversize from both screens is fed to a picking belt, where it is sorted and waste discarded. The minus five-eighths in. material is washed and fed to a two-cell, 42-in. Bendolari jig with a 10-mesh screen on the bed. Ore which is plus 10-mesh is recovered from the bed by scalping cups, and the minus 10-mesh concentrates is collected in the hutch. The jig concentrate from the hutch is run over riffles, as a final operation.

It is planned to replace the riffles by the use of flotation in the near future, as this will give a cleaner product and will not entail the necessity of breaking the continual flow in order to clean up.

All the water used in the operation is kept in a closed circuit by dewatering the jig and riffle tails. A 50-ft. Dorr thickener has recently been placed in this circuit, to dewater the slime.

At the present time, 200 tons of about 5-lb. ore per shift are being treated, giving a concentrate which amounts to approximately 18 lbs. of quicksilver per ton. However, this gives a recovery which is lower than is deemed economical. The difficulty will be remedied by producing a 10 to 12-lb. concentrate which, it is hoped, will give an economical

recovery. There is an estimated 1,500,000 tons of available dump material at the New Idria and San Carlos open pits, which varies in grade from 1-5 lb. per ton.

The installation of three additional units, similar to the one now in operation, is planned for the near future. About 750 tons of ore per shift will eventually be treated in all four concentrating units.

FIG. 15. Quicksilver under the site of the old brick shaft furnace at the New Idria Mine, San Benito County. The numerous white spots are globules of quicksilver. More than 8700 flasks of the metal have been recovered from an excavated depth of 80 feet. The ordinary miner's pan gives scale.
Photo by C. F. Tolman.

Where the old Scott and New Idria furnaces once stood, there is now an excavation about 80 feet deep. A few tons of ore are mined here each day, by means of a power shovel, and trucked to the plant a short distance away. Over 8700 flasks have been recovered from this excavation.

At the portal of the 500-ft. level is situated the upper terminal of a 2300-ft. aerial tramway, which transports the ore in 100-lb. buckets to the reduction plant. Here the ore is dumped from the buckets into a primary ore bin, and transported by a conveyor to a 10- by 16-in. jaw crusher. After it is crushed to $1\frac{1}{2}$ in. size, it is carried by a second conveyor belt to a fine-ore bin at the head end of the furnaces.

The ore is fed into two 5- by 56-ft. Gould rotary furnaces by shaker feeder. These furnaces are the original ones installed by Gould in 1917, and are now considered to be too short for the best economy of operation that could be realized; the standard 5-ft. furnace of today is 75 ft. long. They revolve at a speed of about 1 r.p.m., each one having a capacity of about 100 tons per day, depending upon the type of ore being treated. The grade of oil used for firing the furnaces ranges from 14 to 18 gravity; but the company is planning to use cheaper 9 to 14 gravity oil,

electrically preheated (160° to 175° C.). The oil is atomized by air at a pressure of 100 lbs. per sq. in., and heats the firing end of the kiln to a temperature of 1200° F. The oil consumption for each furnace averages 5.44 gal. per ton of ore treated.

The furnace gases, after passing through the dust chambers at the feed end, are drawn through two Sirocco dust collectors by suction fans, and pass into the condensing system at a temperature of 450° F. The condensing system consists of two banks of 16-in. cast iron pipes 32 ft. high, with 10 pipes per bank. Mercury and soot is caught at the bottom of each pair of pipes, in rubber buckets. The gases, after leaving the condensing system, pass through a redwood settling tank and into a concrete tank. From here they pass through two more redwood tanks, whence they are transferred by a tile pipe to the redwood stack.

The mercury and small amount of soot collected in the rubber buckets is treated with unslaked lime on a sloping table, and hoed until as much mercury as it is possible to free has been collected in a cast iron pot below the level of the table. The remaining soot is returned to the furnace and re-run.

All the screening, sorting, and flotation equipment described by Moorehead [1] has been discarded by the present owners, and lies in disuse just south of the structure which houses the furnaces. Two of the furnaces erected by Gould are also idle, but probably could be placed in operation without entailing any great expense, should the need arise. There is an aerial tramway some 10,000 ft. in length, leading to the San Carlos mine; but it has not been operated for a number of years. The expense of putting this tramway back into operating order would be quite high, as the cables would have to be replaced and some of the towers rebuilt.

The company employs from 75 to 80 men.

The following table gives the cost per ton, and the cost per flask for all the operations of the mine during the month of January, 1938. The figures are representative of what can be done with the average low grade quicksilver mine of today, under careful management.

General Operating Costs—January, 1938

Tonnage treated—4833.
Flasks produced—280.
Recovery—4.4 lb. per ton.

Item	*Cost per ton*	*Cost per flask*	*Total*
Mining	$1.81	$31.29	$8,759.66
Transportation	.07	1.26	353.93
Reduction	.75	12.53	3,508.94
General mine expense	.58	10.13	2,836.57
General office expense	.09	1.36	435.99
	$3.28	$56.77	$15,895.09

Bibliography: State Mineralogist Reports I, IV, V, VI, VIII, X, XI, XII, XIII, XV, XXII. Bulletins 27, p. 138; 78, p. 107.

NIESEN GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

[1] Moorehead, W. R., Methods and costs of mining quicksilver ore at the New Idria Mine: U. S. B. M. Information Circular 6462, pp. 9-10, June, 1921.

STAYTON MINE (Formerly Cincinnati)

Location. M. D. M., T. 12 S., R. 7 E., Secs. 5 and 8, about 15 miles east of Hollister, over good road, in the Stayton district.

Ownership. R. B. Knox, Hollister, California.

Production History. 1870-1880, 1920-1921, 1924, 1927-1933, 1935-1939.

This mine is the principal producer of the Stayton mining district, and was first located in 1870. The first operations were an attempt to mine the stibnite present, for the production of antimony. In 1876, the Stayton Mining Company gained control of the property, and is said to have produced about 1000 flasks prior to 1880. The high prices of 1917 caused the Stayton Company to reopen their property with a view towards installing a furnace and developing the mine. However, when the price of quicksilver dropped following the War, the Stayton Company ceased operations. Mr. R. B. Knox reported production in small amounts intermittently from 1920 to 1939.

General Geology. The country rocks of the region consist of metamorphosed sandstone overlain by basalt flows and acitic tuff breccias. These rocks are cut by a series of veins which have an approximate north-south strike and dip 60° W. The ore occurs as cinnabar, associated with quartz, pyrite, and stibnite, generally on the footwall of the veins, with fissures extending westward into the country rock on the hangingwall.

Bibliography: State Mineralogist Reports X, p. 515; XV, p. 670. Bulletins 27, p. 147; 78, p. 120.

TIRADO GROUP

Location. M. D. M., T. 18 S., R. 12 E., Sec. 18, in the New Idria district, about 2½ miles northeast of the Alpine mine by trail.

Ownership. Ben and Paul Hilden, Hernandez, California.

Production History. 1915-1919.

Late in 1914, Silvester Tirado followed some float up from the Alpine mine, and made the original locations. The property was operated by Jose Tirado from 1915 through 1919, but only a few flasks of metal were recovered in retorts. The property is idle.

General Geology. The ore zone is an extension of the zone described at the Alpine and Hernandez mines. In only one spot was the ore apparently in place.

Bibliography: State Mineralogist Reports XV, p. 670; XXII, p. 244. Bulletin 78, p. 121.

TIRADO and SHEAR GROUP

Location. Two claims, south of Sampson Peak on branch of Clear Creek, 2½ miles southwest of New Idria mine.

Ownership. Last reported owners (1926), S. Tirado and Wm. Shear, Hernandez, California.

Production History. This prospect was discovered in 1925, and some work was done by open-cut mining on the outcrop. One flask of quicksilver was produced from a 2-pipe retort. Idle.

Bibliography: State Mineralogist Report XXII, p. 244.

VALLEY VIEW MINE

Location. M. D. M., T. 15 S., R. 10 E., Sec. —, about 2 miles north of Llanada in east central San Benito County.

Ownership. Louis Schiochetti and George Valdez, Paicines, California.

Production History. 1939.

This property was discovered during 1939 and it is reported that development work consists of a 100-ft. tunnel. A few flasks of quicksilver have been produced with the use of a 2-pipe retort.

General Geology. Very little information was obtainable on the local geologic features of the property other than the report that the ore is metacinnabar occurring in quartz.

WONDER MINE

Location. M. D. M., T. 17 S., R. 12 E., Sec. 31, about $1\frac{1}{2}$ miles west of New Idria, at an elevation of 4000 feet.

Ownership. Paul Gonzales.

Production History. 1913-1917, 1931-1933, 1939.

The property was discovered in 1908, but did not produce until 1913. From this date through 1917, Manuel Gonzales and his sons produced over 100 flasks, using a crude retort to reduce the ore. The property then remained idle until 1931. At this time it was operated by George W. McCutcheon, and a small production is reported for this period ending in 1933. In 1939, Gonzales prospected some new claims, filed on the property and produced a little quicksilver.

General Geology. This mine lies within the Franciscan serpentine belt near the New Idria mine. The ore is cinnabar occurring in seams in a soft, altered sandstone.

Bibliography: State Mineralogist Report XV, p. 671. Bulletin 78, p. 122.

SAN BERNARDINO COUNTY

(See under Other Counties and Mines, page 476.)

DESERT MERCURY GROUP

(See under Other Counties and Mines, page 476.)

IDRIA QUICKSILVER GROUP

(See under Other Counties and Mines, page 476.)

MERCURY GROUP

(See under Other Counties and Mines, page 476.)

SAN FRANCISCO COUNTY

(See under Other Counties and Mines, page 476.)

SAN LUIS OBISPO COUNTY

San Luis Obispo County ranks sixth among California counties in total production of quicksilver. The total production to the close of 1938 is recorded as 71,382 flasks. The next lowest ranking county does not even approach this figure; consequently, this county may be considered among the six great producing counties of the State.

The county may be divided into two main producing sections. The more productive section lies in the Santa Lucia Range, in the northwest corner of the county, and includes the Oceanic, Adelaida, Pine Mountain, and San Carpojaro mining districts. Such well known mines as the Oceanic and Klau are in this section, besides many smaller mines. The second section includes two mines, the Rinconada and the Deer Trail, lying within 15 miles of each other and located in the central and south central portions of the county. The Oceanic mine has been the leading producer to date, closely followed by the Klau mine.

CAMBRIA MINE (Formerly Bank Mine)

Location. M. D. M., T. 26 S., R. 8 E., Sec. 36, about 13 miles by road north of Cambria, and 11 miles from San Simeon, in the Pine Mountain district.

Ownership. Hamilton Carhartt, Jr., Pasadena, California.

Production History. 1903, 1906-1907, 1910, 1915-1916, 1932-1933.

The first recorded activity on this property was by E. S. Rigdon in 1903. Rigdon sold the mine to the Cambria Quicksilver Company (H. R. Gage, president) in 1905, but during the first year only development work was done. From 1906 to 1908, a fair production was recorded, but the ore reserves were depleted to the point where the company was forced to shut down. E. S. Rigdon leased the property in 1910, produced a small amount that year, and then ceased operations. With the rapidly rising price of quicksilver in 1915, the Cambria Company reopened the mine, carrying on their operations in virgin ground above the old workings. About 1800 ft. of drifts and cross-cuts were run, and some quicksilver was produced; but at the close of 1916, the mine was again shut down and has been idle since. The most recent work done on the property was by Hamilton Carhartt, Jr., who cleaned up a few flasks in 1932 and 1933, by working on the old furnace and mine dumps.

General Geology. This property is located in typical Franciscan strata, cut by a serpentine intrusion. There are two known ore zones; both are highly brecciated, altered serpentine zones, varying in width from 20 to 40 feet. Cinnabar formed in rich stringers with a siliceous gangue, and as paint on the fracture surfaces of serpentine fragments.

Bibliography: State Mineralogist Report XV, p. 700; XXI, p. 530; XXXI, p. 435. Bulletins 27, p. 154; 78, p. 128.

CAPITOLA MINE (Now part of Klau mine)

Location. M. D. M., T. 26 S., R. 10 E., Sec. 33, now comprising the eastern part of the Klau mine.

Production History. 1913-1916.

This property was absorbed by the Klau interests, some time after 1918 and prior to 1925. However, from 1913 to 1916, it was operated as an individual mine. Felipe Vilhegas located the claim, which is on an extension of the Klau orebody, in 1913. He leased to William Lane and Charles Pemberton in 1915 and 1916, and a small production was reported.

General Geology. See Klau mine.

Bibliography: State Mineralogist Report XV, p. 706, Chapter rep. bien. period, 1915-1916, p. 112. Bulletins 27, p. 166; 78, p. 132.

CLAUS GROUP

(See under Other Counties and Mines, page 476.)

CYPRESS MOUNTAIN GROUP

(See under Other Counties and Mines, page 476.)

DEER TRAIL MINE

Location. M. D. M., T. 32 S., R. 16 E., Sec. 32, about 7 miles east of Huasana and 20 miles from Arroyo Grande, in southern San Luis Obispo County.

Ownership. M. H. Stevens, San Luis Obispo, California.

Production History. 1916, 1928, 1932, 1935-1936, 1938-1939.

This mine is singular in that it is located in the southern part of the county, far from the main producing districts which are bunched in the northwestern corner of the county.

The mine was located in 1915, and is said to have produced about 70 flasks in 1916. However, no further development was done, and the property remained idle for a long time. In 1928, J. D. Adams reported a very small production; and in 1931, the property was taken over by A. H. McCarthy, John C. Freeman, and J. Beatham, who organized under the name of the Almo Mercury Corporation. Their production was small in 1932, and the mine again dropped off the list of producers. In 1935 and 1936, the property was leased by R. Vehue, who produced small amounts by using a 2-pipe Rossi retort. J. H. Anderson and E. C. Ashhurst leased the property in 1938 and produced a few flasks. During 1939 Pedro Ferrel, of Santa Maria, reported a small production.

General Geology. The country rock of the region is a metamorphosed sandstone, which is fairly well brecciated. In the sandstone is a series of calcite veins, and the ore is found as cinnabar in seams and vugs within the calcite.

Bibliography: State Mineralogist Reports XXI, p. 530; XXXI, p. 435. Bulletin 78, p. 133.

DOTY and QUIEN SABE GROUP

Location. M. D. M., T. 26 S., R. 8 E., Sec. 14, about 16 miles north of Cambria in the Pine Mountain district.

Ownership. Joe Bianchi, Cambria, California.

Production History. 1905-?-1917.

A little work was done on these claims between the years 1905 and 1917. However, since that time the property has been abandoned.

Bibliography: State Mineralogist Reports XV, p. 706; XXI, p. 531. Bulletins 27, p. 156; 78, p. 133.

ELIZABETH and WINONA GROUP

(See under Other Counties and Mines, page 476.)

FITZHUGH RANCH MINE (Formerly Benton Ranch or Lehman Mine)

Location. M. D. M., T. 27 S., R. 9 E., Sec. 13, about 12 miles east of Cambria in the Oceanic district.

Ownership. William Fitzhugh and son, Cambria, California.

Production History. 1933 (small).

The property was originally developed many years ago, but no metal was produced until 1933. In that year, Bucklin and Witcher took a lease on the property, and did a small amount of development work. A small production was reported by them.

General Geology. The mine lies on an extension of the "mud-rock" zone found at the Oceanic mine.

Bibliography: State Mineralogist Reports XV, p. 711; XXXI, p. 437. Bulletins 27, p. 161; 78, p. 127.

JOSEPHINE GROUP (Also Tartaglia or George)

Location. M. D. M., T. 27 S., R. 10 E., Secs. 16, 21, about 20 miles west of Paso Robles, in the Adelaida district.

Ownership. Joe Tartaglia, San Luis Obispo, California.

Production History. 1862-?

The mine was discovered in 1862, and it produced some metal for a few succeeding years. Assessment work was kept up for a number of years, but the mine is now abandoned. The geology is similar to that of the Little Bonanza, near by.

Bibliography: State Mineralogist Report V, p. 95; XIII, p. 600; XVII, p. 720; XXI, p. 531. Bulletins 27, p. 157; 78, p. 134.

KEYSTONE MINE

Location. M. D. M., T. 26 S., R. 8 E., Sec. 13, about 16 miles by road east of San Simeon, in the Pine Mountain district.

Ownership. Last reported owner (1918), Phelan brothers, Cambria, California.

Production History. 1875.

The mine was located in the early 1870's, and by 1874 a coarse-ore brick furnace was completed. The production for 1875 is reported as 60 flasks, and there is no recorded data for any further production. The only activity on the property after 1875 was some prospecting done by the owners in 1916 and 1917.

General Geology. Here, as in most of the mines of the district, the ore occurs in a highly altered serpentine, with an impervious black clay which served as a trap for the mineralizing solutions.

Bibliography: State Mineralogist Reports XIII, p. 600; XV, p. 707; XXI, p. 531. Bulletin 78, p. 134.

KISMET GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

KLAU MINE (Formerly Sunderland, Santa Cruz, Karl, Sierra Morena, and Carson)

Location. M. D. M., T. 26 S., R. 10 E., Sec. 33, about 17 miles by county road west of Paso Robles, in the Santa Lucia Range. The mine and plant lie on a steep hillside just off the road leading to Cambria, 15 miles over the range.

Ownership and Staff. Owner: Mrs. Ellard W. Carson; lessee: Klau Mines, Incorporated, 10 Penthouse, Mills Building, San Francisco, California. H. W. Gould, general manager.

Production History. 1874-1879, 1895-1899, 1901-1912, 1915-1917, 1920, 1924, 1927-—.

In 1868, the original claim was located, and 6 years later the mine entered the producing list. Recorded figures are not available prior to 1875, but the production for the four-year period to 1879 amounted to 4277 flasks.[1] The property was closed down in 1879 and remained idle for many years. A few years prior to 1895, E. Smith reopened the mine and planned an extensive development program. He started actual production in 1895 and continued to 1899, averaging about 350 flasks annually for the last two years of that period. In 1901, the Karl Quicksilver Mining Company purchased the property, erected a 60-ton Scott furnace, and started production on such a scale that by 1903, the mine was the leading producer in San Luis Obispo County, and fourth largest producer in the State, with a recorded production of 3000 flasks for that year. Operations were continued at high speed until the close of 1905. From this date to 1909, production gradually decreased. The Sierra Morena Mining and Refining Corporation acquired the property in 1909, and operated intermittently until 1912. The previous year a fire had razed the wooden structure surrounding the Scott furnace. Another period of inactivity followed, broken only during the War period by a lessee who confined himself to searching for rich pockets in

FIG. 16. Caved ground and old workings, Klau Mine, San Luis Obispo County. Scale shown by figure in circle.

the outcrop, and by the owners who reclaimed a little ore around old stopes. No production was recorded during 1918 and 1919, but in 1920 the property was sold to the Carson Quicksilver Mining Company, with Ellard W. Carson as general manager. That year, a new Scott furnace was erected and placed in operation on September 1. The mine operations consisted of development work, and the ore from this work was

[1] Figures on production prior to 1900 from: Schuette, C. N., U. S. Bur. Mines Bull. 335, 1931.

run through the furnace, giving a production of 47 flasks for the year. The following year, the price of quicksilver fell and the Klau was forced to close. Except for a brief time in 1924, when a few flasks were produced from retorted ore, the mine remained idle until 1927. From this year to 1934, a small but steady production was reported by E. W. Carson and lessees. The total for the seven-year period amounted to 491 flasks, of which 107 were reported from the Capitola property (previously absorbed by the Klau interests) in 1932.

In August of 1934, the mine was leased by the Klau Mines, Incorporated, headed by H. W. Gould and R. A. Hanahan. By January of 1935, a Gould rotary furnace and condensing system were in operation, and from that date production has been continuous. At the present time development work is in progress.

Geology. The Klau mine and adjoining claims lie in an area of Franciscan sandstone and highly altered serpentine. A fault zone through the property strikes northwest and carries three ore shoots, very nearly parallel, with approximately the same strike as the fault zone, and with northeast dips. The two ore shoots to the southwest in the zone have been developed to a vertical depth of 200 ft., while the third has yet to be explored to any great degree.

In the zone of disturbance the country rock is very highly brecciated, and cinnabar, in crystalline form, has been deposited here in fissure fillings and on the fracture faces of the sandstone, between walls of heavy impervious clay which may be a fault gouge. Occasionally, large boulders of chert are encountered which contain cinnabar deposited on the fracture faces, and in some places the less disturbed sandstone underneath the clay is impregnated to a certain degree by the mineral. Pyrite is found as a close and abundant associate of cinnabar in all the mineralized areas of the mine.

The mineralized zone has been developed for a length of not over 500 ft., and to date has proven to be from 200 to 300 ft. in width. The extension to the southeast either becomes wider or splits, so that the Mahoney mine lies on one branch and the Capitola on the other.

Mine and Plant. The present operators are working the mine through an incline shaft with a varying dip of 16° to 24° to the north. The collar of the shaft is located in the bottom of a ravine about 150 ft. west of north from the plant and, because of this location, trouble was encountered in former times with water flooding the lowermost workings during rainstorms. Now, a 20-in. pipe diverts the water from the bed of the ravine, and only in exceptional weather is the inflow of water to the mine greater than the pumps can handle.

Present mining operations consist of extracting ore that has been left in the vicinity of the old No. 5 stope and the old Pierson stope. Little support for the ground is needed in upper workings, as it holds quite well with an occasional stull. However, the workings at the bottom of the incline are partially in an area of heavy clay which must be well timbered to prevent it from sluffing. The management plans to sink the incline into virgin ground, and stope up underneath all the old workings. The bottom of the ore zone has not been reached, because former operators found that the influx of water, at a depth of more than 200 ft., was enough to discourage mining. However, with

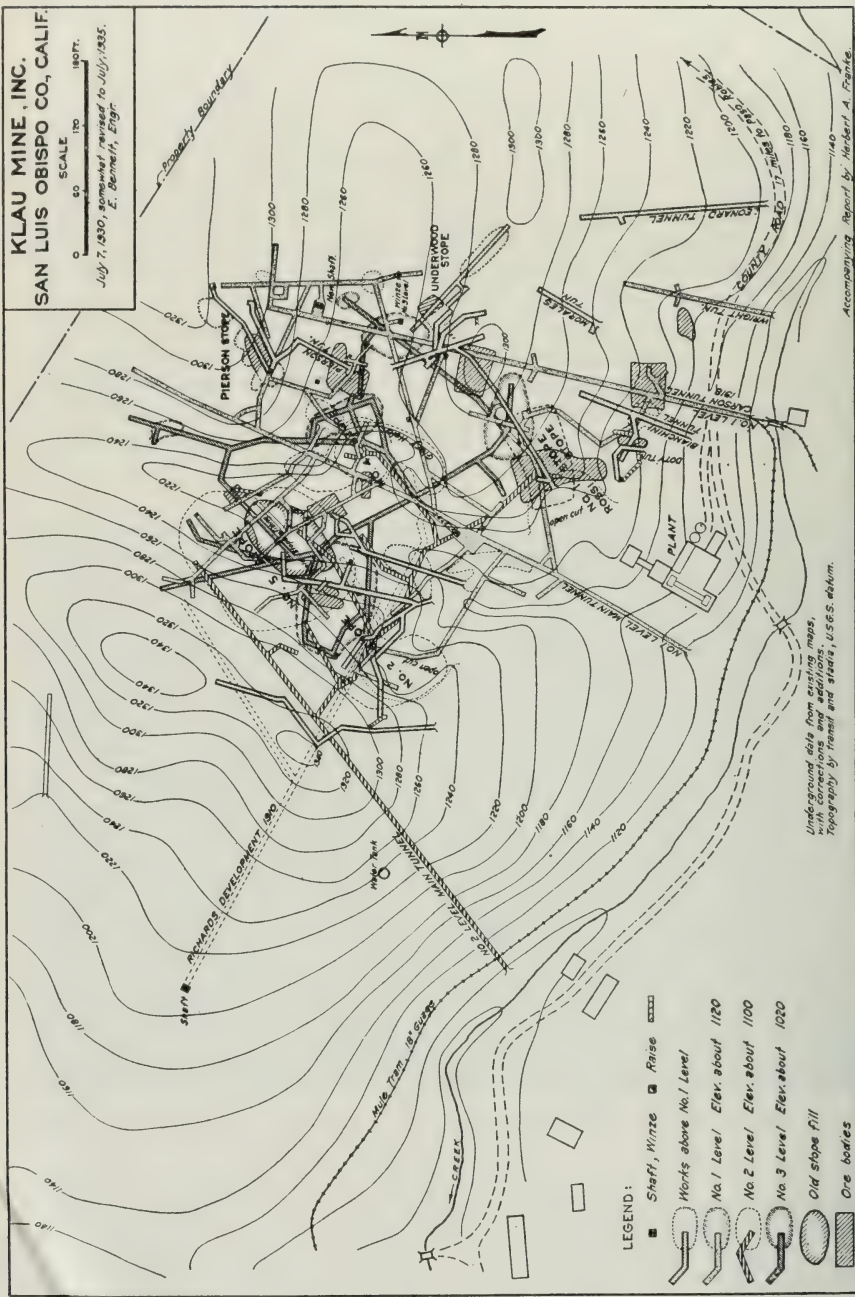


FIG. 17. Map of Klau Mine, San Luis Obispo County. (*Reprinted from a report by Herbert A. Franke, State Mineralogist's Rept. XXXI, p. 438.*)

improved drainage methods and a better pumping system, it is believed that the untouched ore can now be made available.

The ore from the stopes is all dropped through raises to the lowermost level. From this point it is hand trammed to the incline shaft, and hoisted to the surface in ¾-ton cars by a small gasoline hoist. From the collar of the shaft it is hand trammed 150 ft. to the primary ore bin. A 10- by 12-in. jaw crusher at the primary bin reduces the ore to 2-in. size, and a conveyor belt carries the fines and crushed product to a 50-ton fine-ore bin. It is fed to a 3- by 40-ft. Gould rotary furnace of 40 tons capacity, by a shaker feeder. A suction fan pulls the dust and gasses through a Sirocco dust collector and into the condensing system, which consists of two banks of 8 vertical cast iron pipes 16 in. in diameter. At the end of the condensing system are two 10- by 20-ft. redwood settling tanks with pachuca bottoms, and a 20-ft. redwood stack in the last settling tank.

Mercury and soot from the condensing pipes are collected in rubber buckets, and hoed with unslaked lime until as much mercury is freed as possible. The remaining soot is returned to the feed end of the furnace.

The fuel oil used for firing the furnace varies from 14 to 18 gravity, and costs 3.04 cents per gal. at the mine (1938). During 1937, the fuel consumption amounted to 6.48 gal. per ton of ore treated.

The table below gives the unsegregated costs per ton for mining, development, and reduction for 1937.

Mining and Milling Costs—1937

(Includes supervision and management)

Tonnage, 1000 per month

Item	*Cost per ton*
Mining and development	$2.02
Milling	1.04
Overhead	.38
Total	$3.44

During 1938, 20 men were employed on the property—13 underground, 4 on top, and 3 in the plant.

Bibliography: State Mineralogist Reports I, p. 27; XV, p. 709; XVII, p. 385; XXI, p. 531; XXXI, p. 437. Bulletins 27, p. 157; 78, pp. 135-138.

LA LIBERTAD MINE (Also known as Thompson mine)

Location. M. D. M., T. 27 S., R. 10 E., Sec. 21, about 20 miles west of Paso Robles, in the Adelaida district.

Ownership. C. C. Thompson, 7X Ranch, Adelaida, California.

Production History. 1901-1903, 1915-1916, 1935.

The production first recorded from this property was in 1901, 1902, and 1903. During the War years, the mine was operated under lease by the Belt Quicksilver Mining Company. The property remained idle until 1935, when E. E. Lynch moved his reduction equipment from the the old Mahoney mine and started operations.

General Geology. Cinnabar is found as small crystals associated with siliceous material in a highly altered and brecciated serpentine.

Bibliography: State Mineralogist Reports V, p. 95; XV, p. 700; XXI, p. 532; XXXI, p. 437. Bulletins 27, p. 159; 78, p. 138.

LITTLE BONANZA MINE (Formerly Josephine; later Alice and Modoc)

Location. M. D. M., T. 27 S., R. 10 E., Sec. 17, about 20 miles by road west of Paso Robles, in the Adelaida district. The mine is about 3 miles southwest of the Klau mine.

Ownership. Earl Merrifield, Adelaida, California; and the Ruby Davis Estate, care of F. H. Benson, San Jose, California.

Production History. Pre-1900 (small), 1900, 1902-1905, 1915-1916, 1931-1934, 1937-1938.

Mexicans first located the claims in 1862; this group is the oldest in the county. Previous to 1900, the production was small. The greatest activity took place when Barron and Company, of the New Almaden mine, purchased the property and spent a considerable amount of money on development. The reopening of the New Almaden, and an adverse report on the Josephine property, caused Barron and Company to cease operations and abandon the mine. In 1900 and from 1902 to 1906, the property, then known as the Alice and Modoc, was operated by the Consolidated Mining Company. Over a thousand flasks are recorded for this period of operations. In 1915 and 1916, E. S. Rigdon and E. Bianchini leased the mine, but were able to produce only a small amount. The property then remained idle until 1931. At this time, L. D. Purdy took a lease on the property and produced a few flasks. In the following year, E. M. Merrifield operated and in 1933, Ed Dodd leased the land and recorded a small production. In 1934, Merrifield again worked on the property. The group of claims includes the old Alice, Alice No. 2, Ida, Echo, and a portion of the Modoc. Some of these claims originally comprised the Elizabeth and Winona group. The recent work in 1938 has been done by lessees.

General Geology. The ore occurs as cinnabar in a network of seams, and on fracture faces of a greatly altered and silicified serpentine.

Bibliography: State Mineralogist Reports XV, p. 711; XXI, p. 532; XXXI, p. 441. Bulletins 27, p. 155; 78, p. 138.

MADRONE MINE

Location. M. D. M., T. 27 S., R. 10 E., Sec. 22, about 20 miles by road west of Paso Robles, adjacent to La Libertad mine in the Adelaida district.

Ownership. Harry Marquat, Cayucos, California.

Production History. 1900.

The only known production was made in 1900, when some superficial work was done. Since that time the property has remained idle.

General Geology. The ore is similar to that found in the Little Bonanza and La Libertad mines; it occurs in a siliceous altered serpentine. Very little depth was ever reached in any of the workings.

Bibliography: State Mineralogist Reports XV, p. 712; XXI, p. 533; XXXI, p. 442. Bulletins 27, p. 161; 78, p. 139.

MAHONEY MINE (Also Gould or Buena Vista)

Location. M. D. M., T. 26 S., R. 10 E., Sec. 33, about 14 miles west of Paso Robles, southeast of the Klau mine in the Adelaida district.

Ownership. Miss Mary I. O'Toole, Gilroy, California.

Production History. 1900-1903, 1929-1930, 1935, 1938-1939.

The first recorded production was made between 1900 and 1903, when the property was operated under the name of Buena Vista by McKeown and Ronado of Adelaida. After 1903, the mine was idle for 26 years. In 1929 and 1930 the Premier Metals Corporation occupied the property and produced a small amount. In 1935, E. E. Lynch produced a few flasks and then gave up his lease. In 1938, Mr. Houser of San Jose, operated the mine under option and produced a few flasks. During 1939, Roy Wyatt, of Adelaida, leased the property and produced a small amount.

General Geology. The geology of the Mahoney mine is similar to that of the Klau, since it is located on an extension of the Klau ore zone. No large ore bodies were ever found, and most of the ore has come in bunches in a partially indurated clay mixed with sandstone boulders.

Bibliography: State Mineralogist Reports XV, p. 712; XXI, p. 533; XXXI, p. 442. Bulletins 27, p. 161; 78, p. 140.

MARQUART RANCH PROSPECT

(See under Other Counties and Mines, page 476.)

NORTH STAR MINE

(See under Other Counties and Mines, page 476.)

OCEANIC MINE

Location. M. D. M., T. 27 S., R. 9 E., Secs. 15 and 21, about 40 miles by paved highway north of San Luis Obispo, and 5 miles east of Cambria. The mine lies on the west slope of the Santa Lucia Range at an elevation of about 500 ft. above sea level.

Ownership and Staff. Anglo American Mining Corporation, Ltd., 206 Sansome Street, San Francisco. H. W. Klipstein, executive vice-president; A. W. Frolli, general manager; M. J. O'Boyle, superintendent.

The Consolidated Mining and Milling Corporation, headed by William N. Albee of Detroit, obtained an option on the Oceanic mine in March, 1938, but this option was not retained.

Production History. 1865, 1875-1882, 1902-1920, 1927-1932, 1934-1938.

The three original claims of this property were located in the early sixties, and a patent on them was granted by President Lincoln in 1865. Not until 1875, when the property was acquired by a large corporation, was there any appreciable production made. The owners then went ahead on a large scale, erected a Louis Janin furnace, and operated continuously until 1882. Because of the sharp decrease in the price of quicksilver, the operators were forced to curtail production, and by 1882 the mine was closed down entirely. The total recorded production up to this date amounted to 7391 flasks.

For a period of 20 years the Oceanic remained idle, and in 1902 a new company purchased the property. A 50-ton Scott furnace was

erected, and an operating era was started which lasted until 1920. No break was made in production during this period, although the mine changed hands several times. Through the years 1909, 1910, and 1911, production was made by lessees. At this time the property appeared to be mined out, since nearly all the high grade ore found in the coarse-grained sandstone was gone.

The following year, Murray Innes of San Francisco purchased the mine, and proceeded to develop a large tonnage of low grade ore in a very fine-grained sandstone, locally known as "mudrock." Innes operated until 1916, after rebuilding the Scott furnace, and then gave a bond on the property to Edward Clark et al. of New York. The New York company built a 300-ton concentrating plant, an aerial tramway from the mine to the plant, and a second 50-ton Scott furnace. The concentrating mill consisted of a series of ball mills, classifiers, and shaking tables; but it was never very efficient in operation. Consequently, when Clark released his bond in 1917, and the property reverted to Innes, the mill was dismantled entirely. Innes operated until 1920, at which time the low price of quicksilver again forced a shutdown.

Some development work was done by the Raymond Finance Company in 1925, and at this time methane gas was first noticed in the mine. H. W. Gould acquired the property in 1926, and leased it to the International Mercury Company, who reopened the mine to the 700-ft. level and commenced installing a 4- by 60-ft. rotary furnace and tile condensing system.

The furnace was completed and was ready to operate early in 1928. In the fall of that year, the Mercury Corporation of Nevada started operations with H. W. Gould as manager. Work was continuous under Gould until 1930.

Early in that year the property was purchased by the Consolidated Metals Corporation, which began operations immediately and produced for a period of three years. Because of the low price of quicksilver in 1932, the management deemed it wise to close down the following year. In 1933 the assets of the Consolidated Metals Corporation were acquired by the present owners, the Anglo American Mining Corporation, Ltd. By 1934, operations were again resumed, and production has been continuous to June 1938.

The mine has to its credit a total production of more than 38,000 flasks to the end of 1938.

General Geology. Several articles [1-5] concerning the geology of the Oceanic district have been published within the past 35 years, but in several respects they do not agree.

The rock formations found in the district are intrusive serpentine, Franciscan strata, a series of Miocene (?) sediments, and an igneous

[1] Schuette, C. N., Occurrence of quicksilver orebodies: Trans. A. I. M. E., pp. 430-432, 1931.

[2] Heberlein, C. A., Mining and reduction of quicksilver ore at the Oceanic mine, Cambria, California: Trans. A. I. M. E., p. 498, 1915.

[3] Bradley, W. W., Quicksilver resources of California: Calif. State Min. Bur., Bull. 78, pp. 142-193, 1918.

[4] Forstner, Wm., Quicksilver resources of California: Calif. State Min. Bur., Bull. 27, p. 162, 1903.

[5] Frolli, A. W., Mining and reduction methods and costs at the Oceanic quicksilver mine: U. S. B. M., I. C. 6950, pp. 4-5, 1937.

intrusion of undetermined age. The typical metamorphosed sandstones of the Franciscan series extend northeast from the mine workings. The ore deposition took place in sediments consisting of a light gray, coarse-grained sandstone and conglomerate, and in a very fine-grained shaly sandstone locally known as ''mudrock.'' Ransome [1] states that these sediments probably belong to the Miocene age. At the contact of Miocene (?) and Franciscan strata are some minor faults along which are found small rhyolite intrusions. In the basal Miocene, two outcrops of an igneous intrusion have been noted. Bradley [2] calls one of these a diorite gabbro. According to Frolli,[3] they are sills of diabase intruded into the beds of conglomerates, sandstones, and shales.

The Miocene (?) strata show evidence of considerable folding, as the dip at the surface is to the southeast or vertical, while at depth the dip has reversed and is to the northeast. The strike of the beds is N. 65° W., and the southeastern extension is limited by a large thrust fault which strikes N. 45° W., and has a dip of between 55°-70° NE. The upthrust, or northeast, side of the fault is Franciscan rock, which makes what is generally conceded to be a fault contact with the Miocene (?) strata. All the ore is found in the Miocene (?) sediments, with the orebody having about the same attitude as the sedimentary beds. The orebody pitches to the southeast, has a total length of more than 500 ft., and varies in width from 15 to 40 ft. The hangingwall is defined by a thick gouge above, and by a mere slip in the sandstone below. The footwall, however, is very indefinite as it lies in the fine-grained ''mudrock,'' and varies with the changing grade of its quicksilver content. The southeastern extent of the orebody is limited by the thrust fault and, thus far, no ore has been found within the Franciscan formation.

The ore occurs in two distinct types. The first is known as the high grade type, in which cinnabar is well disseminated throughout the coarse-grained, light gray sandstone previously described. Along fractures in this rock a little local enrichment is found. The second type is the low grade ore and occurs in the very fine grained ''mudrock'' forming the upper part of the Miocene (?) formation. Here the cinnabar has only slightly impregnated the rock, and occurs more commonly as almond-shaped nuggets, slightly tapered stems, and as replacements of fossil shells. The minerals associated with cinnabar in this rock are pyrite, in varying amounts, and considerable calcite.

The theory of mineralization, as presented by Schuette,[4] is that the mineral solutions followed the diabase intrusions into the coarse gray sandstone, and rose through this sandstone until they were deflected by the ''mudrock.'' This finer grained material prevented wholesale impregnation, because of its impervious nature, and is therefore lower in grade.

Mine and Plant.[5] As the oceanic orebody outcrops along the crest of a range, easy entry to the mine is afforded by several adits. Those now open for use are the 200, 300, and 400 levels. This last is the main

[1] Ransome, F. L., Quicksilver: U. S. G. S. Min. Res. of U. S., pt. 1, p. 388, 1917.

[2] Bradley, W. W., op. cit., p. 142.

[3] Frolli, A. W., op. cit., p. 4.

[4] Schuette, C. N., op. cit., p. 432.

[5] The data on the mine and plant are taken from U. S. Bur. Min. Inf. Circ. 6950, by A. W. Frolli, as well as from personal observations by the authors.

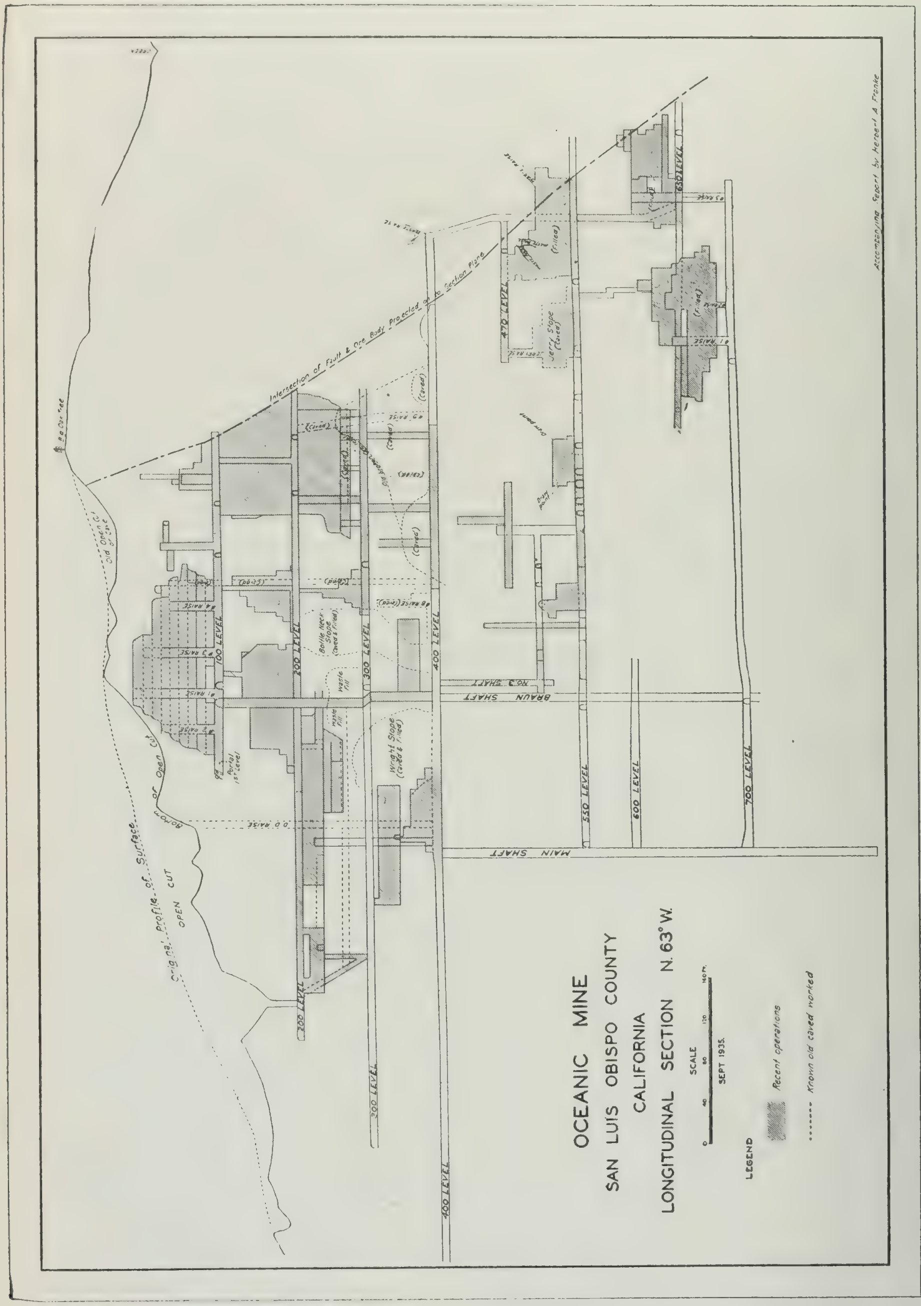


FIG. 18. Longitudinal section through the Oceanic Mine. San Luis Obispo County. (*Reprinted from a report by Herbert A. Franke, State Mineralogist's Rept. XXXI, p. 444.*)

haulage level, through which all the ore mined is transported to the crushing plant at the portal. About 90 ft. south of the orebody, a vertical winze known as the main shaft extends from the 400 level to a depth of 750 ft. below the highest point on the outcrop. The lower workings are accessible through three crosscuts from the main shaft. These are known as the 550, 600, and 750 levels. There is no standard level interval, but it is generally 70 ft. in the upper workings and 50 ft. in the lower workings.

In 1931, A. W. Frolli introduced the top-slice method of mining at this property, and it has worked successfully ever since. The walls are too weak for the use of shrinkage methods, and the ground is too heavy for square setting. The method as applied at the Oceanic consists of spacing cribbed raises 35 to 40 ft. apart, drifting from each raise to the end of the orebody, and then taking out horizontal slices the width of the ore, while working toward the raise. About 20% of the mining has been done by square sets and fill in isolated sections, and in mining pillars that are not suited to the top-slice method. The most recent operations consisted of extracting ore from old filled stopes and abandoned pillars in the upper workings, opening old levels in the lower workings, and stoping low grade ore above the 700 level.

Electric cap lamps and electric primers for blasting are used exclusively underground, because of the occasional presence of methane gas which collects in pockets at the back of unventilated workings.

Ore from the mine is crushed to 2-in. size in two 8- by 10-in. Hercules-Blake jaw crushers, situated outside the portal of the 400 level. It is then transported by a 2600-ft. aerial tramway to the furnace plant at the bottom of the hill. The reduction equipment consists of a 4- by 60-ft. Gould rotary kiln, a No. 12 D type Sirocco dust collector, three condenser units consisting of rows of 16½-in. inside diameter cast iron pipes, two redwood settling tanks, and an 8-ft. D retort. Ore is fed into the kiln at the upper end by a shaker feeder. The kiln revolves at the rate of one revolution in 55 seconds, and a lump of ore passes through in about 45 minutes. It will handle about 75 tons of ore per 24 hours when conditions are favorable; that is, when the ore is not too wet or too fine. Firing is done at the discharge end of the kiln with pre-heated fuel oil pumped to the burner at 90 lb. per sq. in. pressure, and then atomized by air under a pressure of 60 lb. per sq. inch. Kiln temperatures are 1350° F. at the lower end, and 600° F. at the dust chamber. The calcined ore is trammed from a 50-ton concrete bin to the dump in one-ton cars hauled by a small gasoline locomotive.

The mercury and mud, collected in rubber buckets below the condenser pipes, are dried out and hoed with unslaked lime. After about 50% of the mercury is hoed free and collected in a large cast iron receptacle, the remaining mud is placed in the D retort and treated for eight hours. The management feels that this is a more satisfactory method of treatment than merely feeding the mud back into the kiln. The losses realized in the retort are so small that they are negligible. If the rich mud were re-run through the furnace, the stack and dust losses would increase in proportion to the amount of mercury added. The last vertical condenser pipe, the redwood settling tanks, and the base of the stack are continuously water-sprayed on the inside to collect

any small particles of dust and metal which may have passed through the condensing system.

The fuel oil used for firing the kiln and retort is an 18-gravity crude oil which costs $2.124 per barrel, or about 5 cents per gallon. Over a period of time, the furnace consumed an average of 6.3 gal. of oil per ton of ore treated.

The following table shows the mining costs per ton of ore treated in 1935. The tonnage treated for that year is almost identical with the amount mined.

Mining Costs, 1935 (excluding development costs)

Mining method—top slice, 80%; square set, 20%.
Tonnage treated—26,610.

Item	*Cost per ton*
Labor (including mine supervision)	$1.426
Explosives	.079
Timber	.141
Other supplies	.077
Power	.081
Compensation insurance	.121
Total	$1.925

During 1938, an average of 40 men were employed at the Oceanic mine. They were distributed as follows: 32 underground, 1 to 2 on the tramway, and 7 at the crusher and reduction plant.

Bibliography: State Mineralogist Reports, I, V, VIII, XII, XIII, XV, XVII, XXI, XXXI. Bulletins 27, p. 162; 78, p. 140.

PINE MOUNTAIN GROUP (Including Ocean View, Buckeye, and Little Almaden)

Location. M. D. M., T. 26 S., R. 8 E., Secs. 2, 10, 11, on the east slope of Pine Mountain, 11 miles east of San Simeon.

Ownership. Hearst estate, California.

Production History. 1871-?

Production dates are not available for these mines. The first location was made in 1871, and was operated sporadically with no definite production ever noted. After 1900, the properties were abandoned and are now part of the Hearst estate at San Simeon.

General Geology. The country rocks of the region are Franciscan shales and sandstones which have been covered in places by a body of rhyolite, which forms the main mass of Pine Mountain.

Bibliography: State Mineralogist Reports VIII, p. 531; X, p. 580. Bulletins 27, p. 163; 78, p. 146.

POLAR STAR MINE (Also called Santa Clara, or Black Hawk mine)

Location. M. D. M., T. 25 S., R. 6 E., Sec. 13, about 15 miles north of San Simeon, in the San Carpojaro district.

Ownership. Walter Harris, Paso Robles, California.

Production History. 1870-?-1900, 1935.

This mine was discovered in 1870, and operations were sporadic until 1900. Between 1890 and 1900, E. S. Rigdon and others attempted to uncover a vein by hydraulicking, but their efforts were unsuccessful.

In 1915, A. L. Carpenter of San Luis Obispo relocated the claims, but never produced any quicksilver. The mine was idle until 1935, when E. D. Rogers of San Simeon took a lease on the property. Rogers attempted to locate old workings by crosscutting into the hillside, but the bulk of his production came from reworking the dumps. The mine is now idle.

General Geology. Recent exploration has failed to find an ore-body, which must occur in a highly silicified sandstone, judging from the rocks on the dumps. The country rock is altered Franciscan serpentine.

Bibliography: State Mineralogist Reports XV, p. 718; XXXI, p. 449. Bulletins 27, p. 165; 78, p. 147.

RINCONADA MINE (San Jose Valley Mine)

Location. M. D. M., T. 30 S., R. 14 E., Secs. 21 and 28, in San Jose Valley, 11 miles southeast of Santa Margarita. This mine, like the Deer Trail, lies well outside the main producing belt of the county.

Ownership. Mrs. Theresa Bell, Piedmont, California.

Production History. 1872-?-1883, 1897, 1915, 1923, 1925-1926, 1929, 1932, 1934, 1935 (one month), 1936-1937.

The mine was originally located in 1872, and was operated at intervals for 11 years. A crude furnace was installed in 1876, which did not work very efficiently; and in 1883 the mine was abandoned. Operations began anew in 1879, and a little high grade ore was put through pipe retorts. At the end of the year the mine was again closed for an indefinite time. The increasing prices of 1915 stimulated C. T. Claus of Santa Margarita into taking a lease of the property. He did no more than haul a small amount of ore from the mine, treat it in pipe retorts, and thus produce a few flasks of metal. The property remained idle until 1920, when it was sub-leased to the Rinconada Mercury Corporation, headed by George Hathaway. This corporation employed 20 men and installed a 4-by 50-ft. rotary furnace during the year, but soon gave up the lease after treating only a small amount of ore. It is reported that after a few trial runs with the new furnace, a disagreement arose among the operators, and they decided to suspend activities. W. B. Ewalt and A. Ledaboer, who held a previous lease on the property, renewed their lease in 1923, and immediately sub-leased to the Santa Lucia Mining Corporation. The new operators attempted to make improvements on the plant during the following two years, and finally started production late in 1925. A fair production was realized through 1926; but at the end of the year, work was discontinued and the property remained idle until 1929. At this time it was acquired by the Mercury Corporation of America, Ltd., headed by W. M. Downing and Irving Ballard. New equipment was added and considerable development work was done. On October 30, 1930, a fire destroyed the plant; but it was immediately rebuilt and production continued to October, 1932.

At this time dissatisfaction among the operators arose over mining methods, and the company decided to cease operations entirely. E. J. Bartels, of Texas, spent about $16,000 improving the plant and developing the property in 1934; but he ceased operations near the close of the

year. In 1935, a lease on the property was taken by C. W. Erickson, who operated the plant for about one month. He was forced to shut down because the grade of ore was too low to be profitably mined at the existing price of quicksilver. The latest work was done in 1936 and 1937, at which time a very small production was reported by Shaler and Gahan, lessees.

General Geology. The Rinconada is located near the contact of serpentine and Franciscan sandstone. These rocks, in the mineralized zone at least, have been crushed and fractured to some extent. The orebody has been developed for a total length of 400 to 500 ft. in a

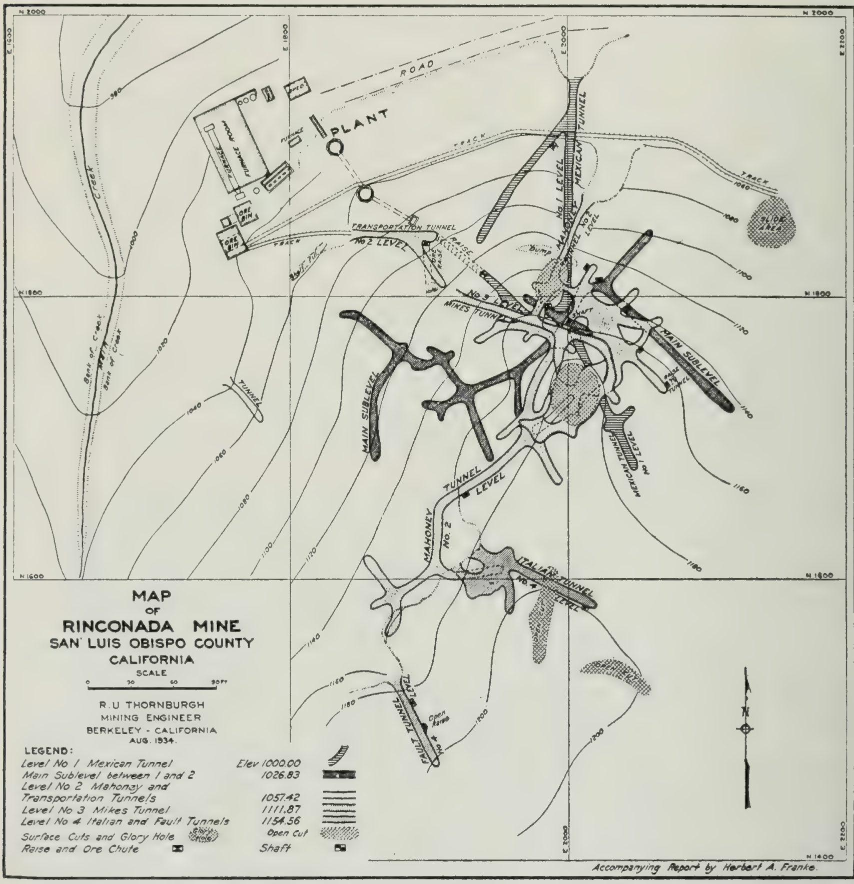


FIG. 19. Map of Rinconada Mine, San Luis Obispo County. *(Reprinted from a report by Herbert A. Franke, State Mineralogist's Rept. XXXI, p. 452.)*

general north-south direction, and, according to a private report made in 1934, there exists an estimated 816,500 tons of 3-lb. ore in sight. One might be inclined to doubt the accuracy of such a statement, as it is almost always impossible to predict the tenor and continuity of cinnabar orebodies. The cinnabar is generally found in fracture fillings closely associated with pyrite, calcite, dolomite, and quartz.

Because there is very little impregnation of the country rock by the mineral, the ore is of lower grade than may appear at first sight. Under small folds of impervious material, local enrichment has taken place, resulting in the formation of small pockets of very high grade ore. The early operations at the mine consisted of searching for and mining these pockets.

Mine and Plant. The Rinconada mine is developed by two main levels, the Mexican tunnel, or No. 1 level, at an elevation of 1000 ft.; and the Mahoney tunnel, or No. 2 level, at an elevation of 1075 ft. These workings run from the north end of the property in a general southerly direction for 300 ft. and 450 ft., respectively. Between them, at an elevation of 1026 ft., is the main sub-level which has a general east-west trend. A glory-hole is excavated from the surface to a point a short distance below the Mahoney tunnel, and ore was extracted in former operations through a raise from the Mexican tunnel. The old No. 3 level, or Mike's tunnel, is now mostly caved, as the glory-hole runs through it. The southern part of the property has been explored by the Italian and Fault tunnels; nevertheless, although ore is reported to have been found, the distance to the plant has seemed too great for profitable mining. The work done by Erickson consisted of extracting ore from the glory-hole and hand tramming it to the portal of the Mexican tunnel. From this point, it was hoisted on an incline track by an air hoist, and then trammed 200 ft. to the primary ore bin.

The reduction equipment on the property consists of a 10- by 14-in. jaw crusher, a 4- by 54-ft. rotary furnace equipped with a shaker feeder, a Sirocco dust collector, a condensing unit with 18-in. diameter cast iron pipes, and two redwood settling tanks. Erickson used a crude fuel oil which cost $0.90 per barrel, for firing the furnace, and he found that his oil consumption varied from 4 to 6½ gals. per ton of ore treated.

Bibliography: State Mineralogist Reports XII, p. 366; XIII, p. 600; XV, p. 719; XVII, p. 386; XXI, p. 534; XXXI, p. 449. Bulletins 27, p. 166; 78, p. 147.

SUNSET VIEW MINE

(See under Other Counties and Mines, page 476.)

VULTURE MINE

(See under Other Counties and Mines, page 476.)

WARREN RANCH

(See under Other Counties and Mines, page 476.)

WILLIAM TELL MINE

(See under Other Counties and Mines, page 476.)

WITTENBERG MINE

(See under Other Counties and Mines, page 476.)

SAN MATEO COUNTY

(See under Other Counties and Mines, page 476.)

SANTA BARBARA COUNTY

Quicksilver mining in Santa Barbara County at the present time is limited to two districts, the Los Prietos district surrounding the Los Prietos mine, and the Cachuma district including the Lion Den mine and the Red Rock mine. The former is located in the Santa Ynez Range, about 8 miles north of the city of Santa Barbara. The latter is in the San Rafael Mountains 12 miles east of Los Olivos.

Total recorded production to the end of 1938 is 2078 flasks, with a fairly even distribution of production from all of the mines.

LION DEN MINE [1] (Also known as Cal-Mer) (Probably includes part of old Santa Rosa property)

Location. S. B. M.,[2] T. 8 N., R. 29 W., Sec. 32, and T. 7 N., R. 29 W., Sec. 5, about 42 miles northeast of the city of Santa Barbara and about 16 miles east of Los Olivos, in the San Rafael Mountains.

Ownership. Lion Den Mercury Company, J. G. Moore, Los Olivos, California.

Production History. 1935, 1937-1939.

Quicksilver ore was first noted either on this property, or in close proximity to it, sometime prior to 1917, when D. D. Davis and Charles Clark did a small amount of development in what was then known as the Santa Rosa mine. Apparently the claim was abandoned, because in 1933, J. G. Moore located a claim on the present deposit, and took in Charles Wood and Loyd Henning as partners. However, nothing was done until 1935, when a man named Ferrel bought Henning's interest. A retort was then erected, and a small amount of surface ore was run through. In March of 1936, Oscar Pfutzner and one de Mandell formed a partnership known as the California Mercury Company (Cal-Mer), and took an option on the property. A 30-ton mill was completed by March, 1937, and active production continued to the end of June, 1937. The property went into receivership. J. G. Moore has operated the property since 1937.

Geology. The Lion Den mine lies on an extension of the Red Rock orebody which adjoins the Lion Den to the south. Intruded into beds of Franciscan sandstone are several serpentine dikes. The ore-bearing area is described as consisting of two parallel, mineralized zones about 100 ft. apart. The present owners have exploited the western zone only. It strikes nearly north-south, and dips about 80° E. It varies in width from 2 to 6 ft., has been proven for a length of about 3000 ft., and has been developed to a depth of not over 100 ft. below the highest point on the outcrop. The zone tends to cut across, rather than to follow, the strike of the serpentine dikes. Mineralization has taken place in zones of highly fractured and altered shale and sandstone between walls of clay gouge. The ore consists of cinnabar in the cementing material between brecciated fragments of shale and sandstone, and in vugs within this same breccia. In general appearance it highly resembles the ore from the New Idria mine.

Mine and Plant. The mine is developed by a 65-ft. adit to the ore zone, a 235-ft. drift along the vein, a crosscut from the vein to the east, a distance of 78 ft., and a 30-ft. winze. Seventy-eight feet of drifting

[1] Data taken from a private report on the property by Herman Fleck.
[2] S. B. M., San Bernardino Meridian.

from the bottom of the winze completes the development. About half the ore mined was extracted from an open cut about 100 ft. above the main level.

The reduction plant consists of a 30-ton rotary furnace with modern condensing system. During the brief period of operation, a very poor recovery of from 60%-70% was made because of improper handling.

The ore which was treated in the mill is said to have run from 5 to 6 lb. of quicksilver per ton.

LOS PRIETOS MINE (Includes the Milburn-McAvoy and Snow groups)

Location. S. B. M., T. 5 N., R. 27 W., Secs. 9, 10, 11, and 12, about 8 miles due north of the city of Santa Barbara, in the Santa Ynez Mountains.

Ownership. Los Prietos Quicksilver Mines Company, Higgins Building, Los Angeles, California. F. M. Townsend, president. T. H. Canfield, manager, La Arcada Bldg., Santa Barbara, California.

Production History. 1860-?, 1874-1877, 1916, 1930-1933, 1935, 1938-—.

The presence of cinnabar in the locality of this mine was first noted in 1860. In 1874, a large furnace was erected, and operations were carried on at quite a large scale for a period of two years. A small amount of work was done in 1877, but, due to the low price of quicksilver, the operators were forced to close down. Not until 1916 was there any further activity on the property. During that year, the mine was purchased by the present owners and a small production was recorded. The property again fell idle and remained so until 1930, when activity resumed and the Los Prietos Quicksilver Company produced a few flasks during that year and the next. In 1933, the property was operated by Edgar Larson, who reported a small production. In 1935, Ray Wyatt reported a fair production. The latest operations were in 1938 and 1939, when a few flasks were reported by T. H. Canfield. The property now consists of two claims, or groups of claims; the Juniper and the Santa Ynez groups. Los Prietos mine proper is on the Juniper claim, and is developed by several open cuts and a series of tunnels and drifts. The Milburn McAvoy workings are on the Santa Ynez group, about 2½ miles east.

General Geology. The following description of the geology is taken from W. Burling Tucker's report:[1]

> "The group of claims is located on a belt of mineralized serpentine which strikes N. 50° W., with a dip of 60° to 70° N., and extends along the range for a distance of four miles. The rock formations are sandstone, conglomerate, and shale of the Coast Range, and the strata are folded and faulted in innumerable dips and directions, but have a general easterly strike, and dip to the north. Traversing this belt of sedimentaries is an intrusive belt of serpentine, on either side of which occurs a ledge formation of highly silicified, crushed shale and sandstone, containing cinnabar in variable amounts. Cinnabar is disseminated through the ledge matter, and is said to average about 0.25%. The average lode width is probably not less than 70 feet, but the broken outcrops in many places cover the surface for widths of several hundred feet. The bold yellow and brown outcrops stand up prominently from the more eroded enclosing rocks, and are visible for miles. Within this lode occur bodies

[1] Tucker, W. Burling, Santa Barbara County: Calif. State Mineralogist's Report XXI, p. 343, October, 1925.

of cinnabar ore at appreciable distances apart, and three of these ore areas have so far been partly opened up."

An interesting sidelight on the general region is that when the Gibraltar Dam was constructed in the vicinity of Los Prietos mine, the resulting reservoir is said to have covered many promising outcrops of cinnabar.

Bibliography: State Mineralogist Reports V, p. 96; X, p. 596; XII, p. 366; XV, p. 746; XVII, p. 389; XXI, p. 543. Bulletins 27, p. 196; 78, p. 150.

MERCUR CLAIM

(See under Other Counties and Mines, page 476.)

RED ROCK MINE (Formerly Cachuma, or Acachuma, and Eagle)

Location. S. B. M., T. 7 N., R. 29 W., NE$\frac{1}{4}$ Sec. 2, about 12 miles by road east of Los Olivos, at the head of Cachuma Creek. Adjoining the property, to the north, is the Lion Den mine.

Ownership. Santa Ynez Mercury Company, Solvang, California; Hans Peters, president.

Production History. 1867-?, 1932-1938.

The original claim, probably known as the Eagle, was located in 1867, and the mine was operated sporadically by the Red Rock Quicksilver Mining Company for several years. There has been only a small amount of sporadic work done on the property, with the latest activity starting in 1932 when O. E. Hanno and one Hanze reported a small production. The present owners operated the property through 1935 and to the close of 1938, making a fair production with the use of a Herreschoff furnace of about 20 tons capacity.

General Geology. The orebody is said to be mineralized serpentine and shale, striking N. 6° E. and dipping 50° E., with a width of about 30 feet. The mineralization consists of stringers and pockets of cinnabar in cross fractures. Along this same general zone is situated the Lion Den mine to the north.

Bibliography: State Mineralogist Reports XV, p. 746; XVII, p. 389; XXI, p. 542. Bulletin 78, p. 150.

STEWARD MINE

(See under Other Counties and Mines, page 476.)

SANTA CLARA COUNTY

In point of total production, Santa Clara County far exceeds all other counties with a yield, to the close of 1938, of 1,149,970 flasks. Almost the entire amount has come from two mines, the New Almaden and the Guadalupe. Due to the closing of these two mines in 1925 and 1919, respectively, production from the county has been very small within recent years.

BERNAL MINE

(See under Other Counties and Mines, page 476.)

BOWIE PROSPECT

(See under Other Counties and Mines, page 476.)

BRAINARD PROSPECT

(See under OTHER COUNTIES AND MINES, page 476.)

COMSTOCK MINE

Location. M. D. M., T. 11 S., R. 7 E., Sec. 19, in the extreme southeastern corner of Santa Clara County in the Stayton district.

Ownership. Last reported owner (1918), T. H. French, Lone Tree, via Hollister, California.

Production History. There is evidence that there was quicksilver produced from this property, possibly as early as 1875. Forstner's * description of the property in 1903 tells of old surface workings and remnants of an old furnace. The mine was abandoned at the time of that report and there is no record of activity since.

General Geology. The Comstock mine is located on the only surface exposure of serpentine found in the Stayton district. The ore is cinnabar occurring in a black chalcedonic material.

Bibliography: State Mineralogist Report XII, p. 367; *Bulletin 27, p. 172; 78, p. 157. Min. Res. W. of Rocky Mts., 1875, p. 14.

COSTELLO MINE

(See under OTHER COUNTIES AND MINES, page 476.)

GUADALUPE MINE

Location. M. D. M., T. 8 S., R. 1 E., Sec. 30. The Guadalupe mine is in the New Almaden district, on the western extension of the New Almaden ore zone. The mine property covers 2500 acres located about 10 miles south of San Jose.

Ownership. Estate of Mrs. J. S. Gregory and the law firms of Young, Hudson, and Rabinowitz; and McKee, Tasheira, and Wahrhaftig.

Production History. 1856-?-1875, 1875-1886, 1901-1906, 1908-1920, 1922, 1932-1934, 1936-—.

The mine was discovered shortly after the initial rise to fame of the New Almaden, and was first worked by the Santa Clara Mining Association in 1856. A reported 20,000 flasks were recovered by 1875, at which time the mine was purchased by the Guadalupe Mining Company. Operations were then continuous to 1886, with many improvements being made in the surface plant. Litigation, starting in 1886, forced the mine into a period of idleness which lasted for the next 14 years. In 1900, H. C. Davey organized the Century Mining Company, and purchased the Guadalupe property. The mine was opened up, the furnace remodeled, and production was started by 1901. Operations continued through 1906, at which time the Century Company was reorganized under the name of New Guadalupe Mining Company. After two years of idleness, production again commenced on a large scale and continued, without a break, to 1920. Litigation at that time again tied up the mine, with the law suit finally being settled in favor of Mrs. J. S. Gregory, recently deceased.

Recent work on the property has consisted of treating the old mine and furnace dumps, as well as underground mining in new locations. The property is now held under lease by the Laco Mining Company, headed by H. N. Mason of Los Gatos.

General Geology. The Guadalupe mine lies on an extension of the New Almaden ore zone, and the geology is fully described in the discussion of the New Almaden mine.

Mine and Plant. The underground workings are now inaccessible, for the most part, because of caving and flooding. They have been described in considerable detail in the literature listed under references. There is no modern reduction plant on the property.

Bibliography: State Mineralogist Reports I, IV, V, VI, VIII, X, XII, XIII, XVII, XXVI. Bulletins 27, p. 173; 78, p. 157.

HILLSDALE, OR SAN JUAN BAUTISTA MINE (Formerly Chapman, then Chaboya)

Location. M. D. M., T. 7 S., R. 1 E., Secs. 33 and 34, about 2 miles southeast of San Jose, on the east slope of the San Juan Bautista Hills.

Production History. 1847-1874, 1892-?-1907, 1915.

This mine was discovered by Mexicans in 1847, and operated by them until 1861. At that time it was purchased by a Mr. Chapman, who operated the mine steadily until 1874. After an 18-year period of idleness, it was reopened by R. H. Harper of San Jose, and produced sporadically until 1907. A small amount of work was done in 1915 by the Discovery Quicksilver Company; but the mine was then abandoned, and has remained idle to the present time.

Bibliography: State Mineralogist Reports XII, p. 367; XIII, p. 600; XVII, p. 213. Bulletins 27, p. 174; 78, p. 160.

NEW ALMADEN MINE (Formerly Chaboya, then Santa Clara mine) (Including the Enriquita and Senator mines)

Although the New Almaden mine has not been operated for some years, it has a record of production of some $75,000,000 in quicksilver during the past century. This record, during the productive span of the mine, was surpassed only by one other mine in the world: Almaden, Spain. The geology, the history of the mine, and the mine plant have been described by so many authors that it would be needless to review these subjects with more than a brief summary.

Location. The New Almaden property covers more than 8000 acres, from 8 to 13 miles east of south from San Jose. This property includes the New Almaden, the Enriquita, and the Senator workings, all of which are generally referred to under the one name, the New Almaden mine.

Ownership. The New Almaden Company, Ltd. George H. Sexton of New York, president. Now worked by a group of lessees headed by P. R. Schneider.

Production History. 1824 (date of discovery), 1845-1925 (1928- —, working over the old dumps and new underground mining).

The New Almaden mine was first worked in 1824; but it was not until 1845 that the production of quicksilver first started on a large scale. The year 1850 is the first in which figures are available for a record that was continuous for 80 years. In 1925, underground operations ceased, the number of flasks for that year being only 973. After a two-year period of inactivity, lessees started working the old dumps of the New Almaden and the Senator mines, producing a few flasks annually up to the present time. The total production of quicksilver

from the mines in the New Almaden property is a recorded 1,039,997 flasks to the end of 1936, including the few flasks gleaned from the old dumps.

General Geology. The three mines included in the New Almaden property are located along the same general mineralized belt, and will be considered together in the resume of the geology.

The first important geological work in this area was done by Becker in 1888,[1] as part of his study of the quicksilver deposits of the Pacific Slope. His observations were very complete and with the excellent illustrations of the then existing orebodies,[2] together form a work of reference that is essentially correct in its details. It is also invaluable from the standpoint of an historical picture of the old workings, now inaccessible.

Franciscan sandstones and shales, probably of Jurassic age, make up the country rock of the region. Along the general northwest-southeast trend of Mine Ridge, these sandstones and shales were intruded at some past geologic age by peridotite. Following the intrusion, which was accompanied by intense fracturing of the rocks, the peridotite was altered to serpentine. Further alteration, undoubtedly from the action of mineralizing thermal waters, developed extensive areas of carbonate-silica rock in this region. There are, generally speaking, two zones of this type of mineralization which resulted in the carbonate-silica rock being formed. The zone from Mine Hill to the Guadalupe mine is only one of the two that has been productive of quicksilver. Some of the carbonate-silica rock is a direct replacement of the serpentine, and the remainder results from an alteration of the sandstone. During this process of alteration, the resulting carbonate-silica rock became incoherent and porous, and it is in this type of rock that the deposition of cinnabar took place.

The footwall of the orebodies is serpentine; the hangingwall is a clay gouge or ''alta'',[3] above which lies the Franciscan sandstones and other sedimentary rocks in the series. All evidence points to the mineralizing solutions being trapped under the clay gouge, resulting in the formation of orebodies. In nearly every case where the ''alta'' is flat lying, high grade deposits were found. In fact, the ''alta'' was recognized as a reliable guide to ore, several extensions to known orebodies having been found by this means.

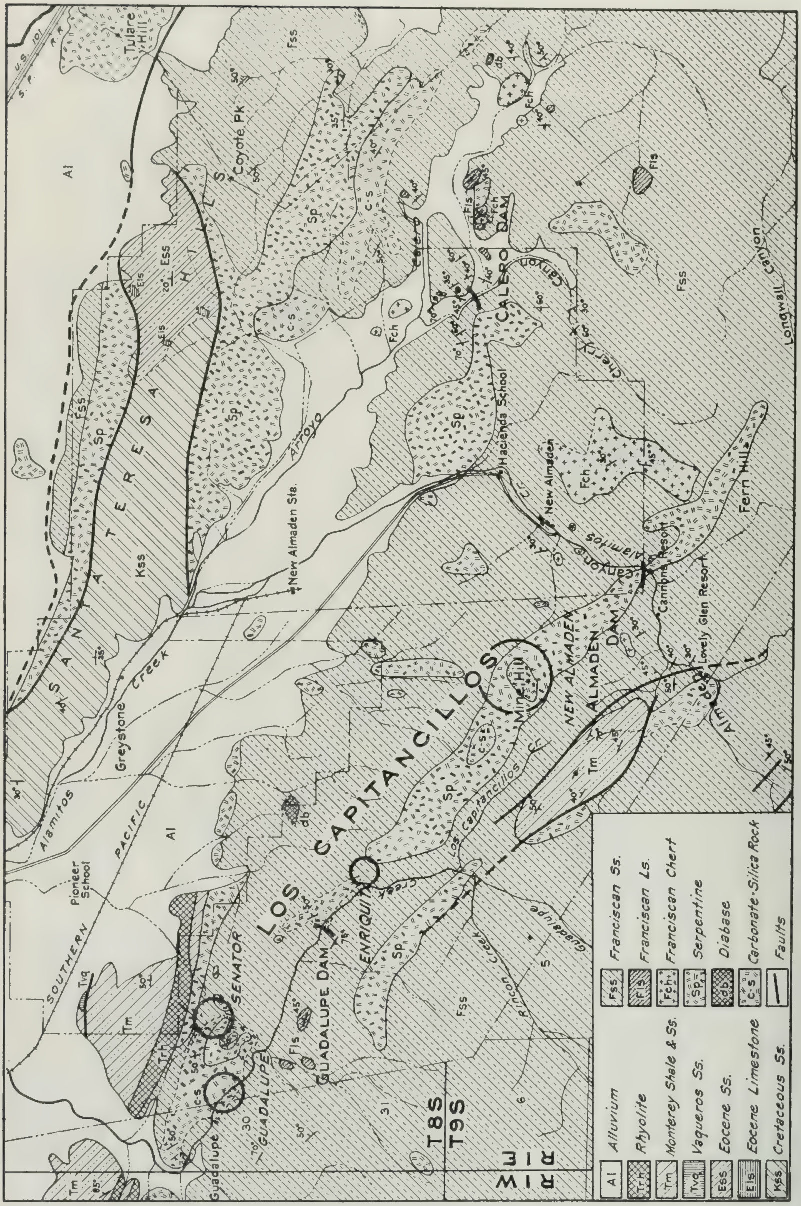
A deep-seated magma is indicated as being the original source of the hot mineralizing solutions. The presence of intrusive diabase and extrusive rhyolite near the mineralized zone, serves as evidence in favor of the above hypothesis. The presence of mineral springs on the property adds strength to this view.

The general picture is one of magmatic intrusion causing movement which resulted in the formation of fissures and accompanying breccia capped by a layer of impervious gouge. Subsequent primary mineralization from the same magmatic source rose through the fractures to the point where conditions were right to form an orebody.

[1] Becker, G. F., Quicksilver deposits of the Pacific Slope: U. S. G. S. Mon. XIII, 1888.

[2] Becker, G. F., op. cit., atlas sheets X, XI, XII.

[3] The term "alta" was used in the early days of quicksilver mining in Calif., to denote usual clay gouge hangingwall.



GENERAL GEOLOGY OF THE NEW ALMADEN DISTRICT, SANTA CLARA COUNTY, CALIFORNIA.

BY JOHN V.S. TOLMAN. STANFORD UNIV., 1934

FIG. 20. Geologic map of the New Almaden District. The circles indicate the general area of the New Almaden, Enriquita, Senator, and Guadalupe mines.

From his observation, Becker states: [1]

"Considered in detail, the ore-bodies are stockworks; but they are arranged along definite fissures and the deposits as a whole have a vein-like character * * *."

The mercury-bearing mineral in the ore is cinnabar; occasionally a small amount of native quicksilver is found occurring with it. Associated minerals include pyrite, quartz, calcite, and dolomite. Opal, chalcedony, and bituminious matter are also characteristic associates in the mineralized zones. The grade of the ore encountered during the early years of mining was high. In 1850 the average was 37%, but this decreased to 18% by 1863. The drop continued gradually, and by 1895 the grade was below 1%.

Mine and Plant. The New Almaden orebodies were unique among quicksilver deposits because of the depth to which they extended below the surface. Continuous orebodies were followed to the 1600-ft. level, and smaller bodies of ore were occasionally encountered at still greater depth. The greatest depth attained during mining operations was 2450 ft. below the top of Mine Hill.

In the area included under the New Almaden property, at least 18 shafts were sunk in order to connect with more than 100 miles of underground workings. Schuette [2] gives a very interesting description of the history of the mining operations, the trouble that was encountered by the inadequate facilities of the old Randal shaft, difficulties with water, and the general prospecting and development problems encountered during the life of the mine.

The development of many metallurgical devices and practices during the last 80 years shows a close relationship to the history of the New Almaden mine. The most important contribution to the industry was the development of the Hüttner-Scott fine-ore furnace, in 1875-1876. In 1916, the first installation of a Herreshoff furnace for the reduction of quicksilver ore was made at the Senator mine.

Bibliography: (Note.—Only a few of the many references are given here. Others will be found in bibliography of the quicksilver resources of California.) State Mineralogist Reports I, VIII, X, XI, XII, XIII, XVII. Bulletins 27, p. 174; 78, pp. 160-167. U. S. G. S. Mon. XIII, pp. 8, 310-330, 467. Trans. A. I. M. E. Gen. Vol., pp. 409-413.

SANTA CLARA MINE (Formerly Piercy property)

Location. M. D. M., T. 8 S., R. 2 E., Sec. 4, about 9 miles southeast of San Jose, just off Fords Road.

Ownership. Santa Clara Quicksilver Corporation, San Jose, California.

Production History. 1930.

This property was opened up by the present owners in 1928, after the mineral rights to the land were acquired from the heirs of the old Miller estate. Under the supervision of Fred D. Murphy, a small production was made in 1930.

Bibliography: State Mineralogist Report XXVI, p. 31.

[1] Becker, G. F., op. cit., p. 437.
[2] Schuette, C. N., op. cit., pp. 409-413.

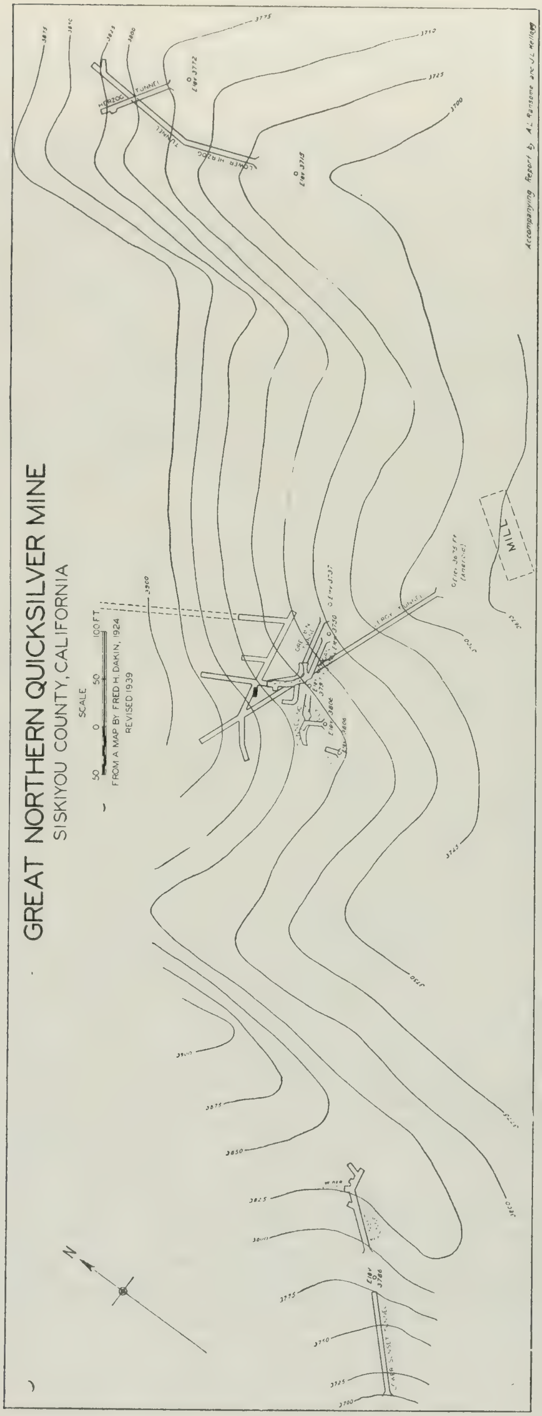


FIG. 21. Map of Great Northern Mine, Siskiyou County.

SANTA TERESA MINE

(See under Other Counties and Mines, page 476.)

SILVER CREEK MINE (Also known as North Almaden mine)

Location. M. D. M., T. 7 S., R. 2 E., Sec. 33, approximately 12 miles by road southeast of San Jose. The property lies on the east side of Silver Creek, about 4 miles east of New Almaden.

Ownership. William Biaggi, San Jose, California. L. A. Purinton, lessee.

Production History. Pre-1918, 1929-1930, 1938.

Dates of discovery and first operations of this mine are uncertain, although it is known that prior to 1918 it was abandoned as being worked out. In 1929, William Biaggi did some prospecting on the property, and produced a few flasks of quicksilver in 1930. In 1938 a few flasks were produced by a lessee.

General Geology. The mine is located on a large landslide which carries either all, or a detached portion, of a cinnabar orebody. Prospecting has failed to locate the source of the orebody.

Bibliography: State Mineralogist Reports XII, p. 367; XIII, p. 601; XVII, p. 225; XXVI, p. 32. Bulletins 27, p. 187; 78, p. 168.

WRIGHT MINE

(See under Other Counties and Mines, page 476.)

SHASTA COUNTY

(See under Other Counties and Mines, page 476.)

CLOVER CREEK MINE

(See under Other Counties and Mines, page 476.)

SISKIYOU COUNTY

Cinnabar deposits have been known in Siskiyou County for a good many years, in fact have been noted near the mouth of Horse Creek, on the Klamath River, since as early as 1878. Later development and exploration have not revealed any deposits of large size in the county.

COWGILL MINE (Formerly Mount Shasta Cinnabar mine)

Location. M. D. M., T. 48 N., R. 9 W., Sec. 34, about 10 miles air line northwest of Gottville, and on the west fork of Beaver Creek.

Ownership. Mrs. A. M. Cowgill, Yreka, California.

Production History. 1917, 1939.

The dates of discovery and first operations on this property are uncertain. Many years ago, a 10-ton furnace was erected and operated by the Siskiyou Quicksilver Mining Company. The mine was operated during the World War (1917), when the Mercury Company of America installed a Johnson-McKay retort. In 1919, litigation over ownership of the property was settled in favor of Mrs. Cowgill, the present owner. The mine has reportedly been put into operation again (1939).

General Geology: The cinnabar, coarsely crystalline, occurs in a wide mineralized zone with sandstone and metamorphic rocks.

Bibliography: State Mineralogist Reports XXI, p. 495; XXXI, p. 336. Bulletin 78, p. 169.

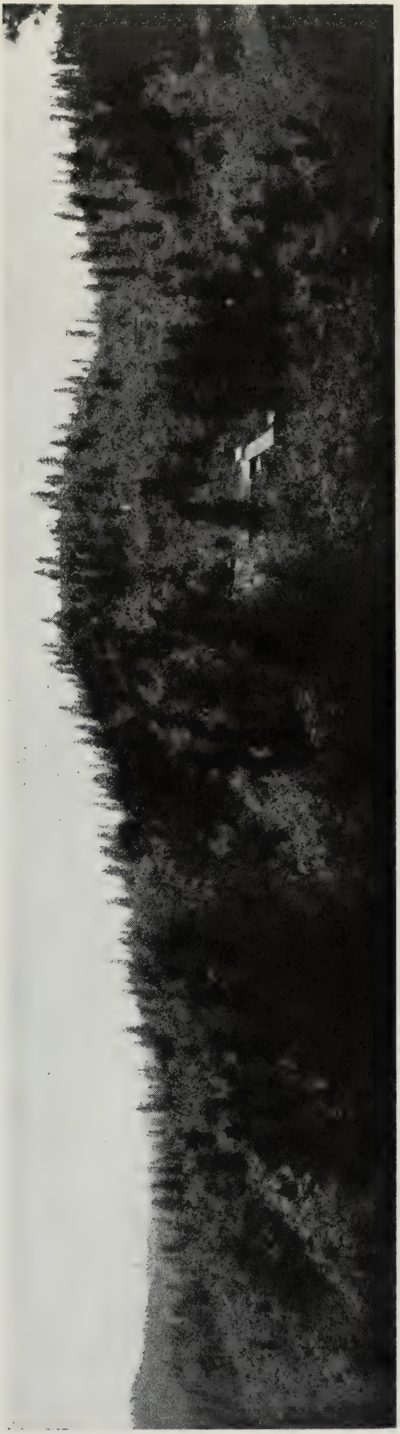


FIG. 22. General view of Great Northern Mine and plant. *Photo by J. W. Humphrey.*

GREAT NORTHERN MINE (Formerly Herzog-Morgan, Minnehaha, then Mercury mine)

Location. M. D. M., T. 47 N., R. 8 W., Secs. 13 and 14, near Klamath railroad station, 21 miles by paved highway and mountain road from Hornbrook.

Ownership. J. C. Humphrey, trustee, San Francisco, California; leased to C. A. Lowe, of Los Angeles, California.

Production History. 1919, 1929-1931, 1939.

The property, encompassed by the Great Northern mine, includes the old Herzog and Morgan mines. Production is first recorded in 1919, when E. T. Jones took over the mine under bond and produced a few flasks. No further production was made until 1929, although Hutton, in 1920, laid plans (which were never realized) to install a rotary furnace. In 1929, the property was acquired by Eugene Aureguy, and production was maintained at a fairly high rate for three years. Aureguy concentrated his ore by flotation, and then retorted the concentrates. In 1935, the property was leased by C. J. Moore, M. J. Orth, and F. A. Riggs, who experimented with a furnace of their own design consisting of a circular rotating hearth. No production is recorded for this period, to the end of 1936. J. C. Humphrey is at present the trustee for the property which is under lease to C. A. Lowe, who, in 1939, installed a Holmes furnace.

General Geology. The geology is similar to the other deposits of Siskiyou County, in that cinnabar has been deposited in an area of metamorphic schists intruded by granodiorite. The ore occurs in fault fissures and shear zones having a general strike of N. 20° E. and a dip of 62° NW. A small amount of native quicksilver is associated with the cinnabar which is found as flakes and narrow streaks along the fracture planes and schistose structure of the rock.

Bibliography: State Mineralogist Reports XXI, p. 496; XXVII, p. 64; XXXI, p. 336.

HORSE CREEK MINE (Formerly Minnehaha, then Barton-Lange mine)

Location. M. D. M., T. 46 N., R. 10 W., Sec. 15, on the Klamath River, near the mouth of Horse Creek, about 5 miles west of Oak Bar.

Ownership. Horse Creek Cinnabar Company, Ltd., Los Angeles, California.

Production History. 1878-?, 1930.

In 1878, cinnabar was first noted in this region; but for a good many years operations were of a very superficial nature only. Some ore was concentrated in 1916, but it was not reduced because of the lack of necessary equipment. The present owners obtained the property in 1930, and installed a continuous process retort which failed to work successfully, because of heating difficulties. There has been no recent activity on the property.

General Geology. The country rocks of this area consist of alternating beds of hornblende and mica-schist that contact a diorite intrusion. Cinnabar occurs in the hornblende series of metamorphic rocks only, as fracture-fillings and paint.

Bibliography: State Mineralogist Reports XIII, p. 602; XIV, p. 870; XXI, p. 496; XXXI, p. 336. Bulletins 27, p. 196; 78, p. 169.

SOLANO COUNTY

There are only two quicksilver mines in Solano County, both of which are now idle. The ore deposits are located on a ridge known as Sulphur Springs Mountain, a few miles northeast of the city of Vallejo.

BROWNLIE MINE

(See under OTHER COUNTIES AND MINES, page 476.)

HASTINGS MINE

Location. M. D. M., T. 3 N., R. 3 W., Sec. 11, about 4 miles, air line, east from Vallejo, and about 2 miles southeast of the St. Johns mine.

Ownership. Hastings Estate.

Production History. 1870-?, 1917-1918, 1928, 1930.

This mine was discovered and operated some time during the seventies. No further production is recorded until 1917, when a lease on the property was taken by A. G. Kullberg. The lease was transferred to the White Investment Company, that year, and the mine was operated until May of 1918, at which time the lease was given up. The property remained idle until 1927, when the Hastings Quicksilver Mining Company took over the property. A small production was made the following year, and again in 1930; but the mine has been idle since. It is reported that the mine was closed by court injunction because of the objection to the mine water by the ranchers in the area.

General Geology. The country rocks surrounding the Hastings mine are similar to those of the St. Johns mine, consisting of Lower Cretaceous sediments intruded by andesitic dikes. The orebody mined is in the brecciated sediments at the contact of an andesitic intrusive. The ore minerals are cinnabar and metacinnabar.

Bibliography: State Mineralogist Reports XIII, p. 599; XXIII, p. 211. Bulletin 78, p. 171.

ST. JOHNS MINE (Formerly Vallejo mine)

Location. M. D. M., T. 4 N., R. 3 W., Sec. 33, about 6 miles northeast from Vallejo, on the ridge forming Sulphur Springs Mountain.

Ownership. Mrs. Clifford Dennis. Lessee, J. C. Lawley, Vallejo, California.

Production History. 1873-1880, 1899-1908, 1914-1919, 1923, 1930, 1936-— (dumps).

The territory composing the St. Johns property was originally a portion of an old Mexican grant known as Soscol Rancho.[1]

In 1852, John Neate first noted cinnabar in this region, and, after sporadic prospecting for many years, a coarse-ore furnace of Neate's design was installed at the mine. Production commenced in 1873, and continued to 1880, when a low price of quicksilver forced a shut down. The following period of idleness lasted for 19 years. In 1899, the property was purchased by the St. Johns Consolidated Quicksilver Mining Company, with Alphonse Tregidgo as superintendent. The mine was opened up and production lasted until 1908, after which time only a few men were employed on the property to keep the mine dewatered and the plant in operating condition. The St. Johns Mines Company,

[1] From a private report on the St. Johns mine by Alphonse Tregidgo. 1911.

headed by Clifford Dennis, purchased the mine in 1914, and produced for the following 6 years when the low price of quicksilver in 1919 again forced the mine into a period of idleness. Operations since the War have been extremely sporadic, and since a fire destroyed the plant in 1925 or 1926, there has been no furnace equipment on the property.

FIG. 23. Sluices, mechanically agitated, St. Johns Mine, Solano County. Fine material from old dumps is passed over these sluices; the resulting concentrate is retorted.

At the present time J. C. Lawley, lessee, is concentrating the old mine dumps with a rough sluice box of his own construction. The concentrates are retorted, and a few flasks a year are thus recovered.

General Geology. The rocks in the area surrounding the St. Johns mine consist, for the most part, of Lower Cretaceous sediments intruded by dikes and small chimneys of meta-andesite. Occasional small intruded masses of serpentine are found scattered throughout the area, but these are of no apparent economic importance. The serpentine has been altered to a carbonate-silica rock in many places.

Orebodies have been formed, in nearly every case, in close association with the andesitic intrusions, with cinnabar in a gangue of quartz and calcite, occurring either as fissure fillings in the interstitial space in a fault brecciated shale near the contact. Where the intrusive and shale is not brecciated, the rock is generally barren of ore.

Bibliography: State Mineralogist Reports I, p. 27; VIII, p. 631; X, p. 661; XIV, p. 311; XVII, p. 246; XXIII, p. 211. Bulletins 27, p. 93; 78, p. 172.

SONOMA COUNTY

Sonoma County is one of the oldest quicksilver producing counties in California; cinnabar deposits were first noted near Pine Flat in the

early sixties. Production has been fairly consistent to the present time, and has reached a total of 77,454 flasks to the end of 1938. This yield ranks Sonoma County fifth among the counties of California in total production to the above date.

There are two principal producing belts in Sonoma County: (1) the western extension of the Mayacmas district, and (2) the district surrounding the Great Eastern and Mount Jackson mines. That section of the Mayacmas district which is in the county, contains such well known mines as the Cloverdale, Socrates, and Culver-Baer, and many smaller properties.

ALMADEN, INCANDESCENT AND TUNNEL SITE GROUPS

(See under OTHER COUNTIES AND MINES, page 476.)

BACON CONSOLIDATED GROUP

(See under LAKE COUNTY, page 385.)

BOSTON GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

BUCKEYE MINE (Mount Vernon)

Location. M. D. M., T. 11 N., R. 9 W., Secs. 3 and 4, adjoining the Cloverdale mine on the east, about 14 miles east of the town of Cloverdale.

Ownership. C. A. Baumeister, Cloverdale.

Production History. 1918, 1923-1929, 1932.

Early production from this mine is credited to the Cloverdale mine, as this claim was formerly the Mount Vernon claim of the Cloverdale group. In 1910, the present owner relocated the claim, but did not produce any quicksilver until in 1918. The mine remained idle for four years, and in 1924, Baumeister again produced some metal. He reported a small production for every year to 1929, and then again in 1932. The property has been idle since that time.

General Geology. The geology greatly resembles that of the adjoining Cloverdale mine.

Bibliography: State Mineralogist Reports XIV, p. 344; XXII, p. 366. Bulletin 78, p. 183.

CINNABAR KING GROUP

Location. M. D. M., T. 10 N., R. 8 W., Sec. 11; 5 patented claims, $2\frac{1}{2}$ miles east of Pine Flat on the west slope of Pine Mountain.

Ownership. Last reported (1918), Cinnabar Mining Company, Eli Bush, treasurer, Healdsburg, California.

Production History. There is no definite record of any quicksilver having been produced. Early accounts of the property speak of an inclined shaft 55 ft. deep and from 600 to 800 ft. of tunnels. As early as 1895, considerable ore was on the dump and a furnace was to have been built in 1896. Work of an indeterminate nature continued until 1910, after which date the mine has been idle.

General Geology. The outcroppings strike NW., the mineralized ledge dipping from 45°-80° SW. The ore is cinnabar in a silicified serpentine, the hangingwall being sandstone and the footwall serpen-

tine. It is stated that ozocerite, a wax-like hydrocarbon, was found associated with the cinnabar.

Bibliography: State Mineralogist Reports XI, p. 461; XII, p. 371; XIII, p. 602; XIV, p. 344. Bulletins 27, p. 98; 78, p. 183.

FIG. 24. Cloverdale Quicksilver Mine, Sonoma County. New concentrating plant above, old furnace plant below.
Photo by Walter W. Bradley.

CLOVERDALE MINE

Location. M. D. M., T. 11 N., R. 9 W., Secs. 3, 4, 9, and 10. This mine is about 13 miles by county road east of Cloverdale, on a high ridge which separates Squaw Creek from Big Sulphur Creek.

Ownership. Charles Cavagnaro Estate, Cloverdale, California, and J. E. Schor, San Francisco. Andrew Rocca, Jr., executor, Bank of America, South San Francisco, California.

Production History. 1875-1881, 1901-1907, 1911-1913, 1915-1925, 1927-1938.

The Cloverdale mine was discovered in 1872, and started producing by 1875, after a furnace was installed. Operations ceased in 1881, after which time the mine remained idle for a number of years. In 1901, the mine was reopened by F. E. Johnson of Napa, and Henry Patten of Calistoga. The property was active until 1907, when it was closed because of the then current low price of quicksilver. It is reported that rock movement accompanying the earthquake of 1906 disclosed an ore-shoot from which $40,000 worth of quicksilver was subsequently extracted. Patten and Johnson operated for a short time from 1911 to 1913, but the mine was again closed down because of the low price of quicksilver. In 1915, the mine was purchased by the Western Mercury Company, headed by Andrew Rocca, Jr. The producing era that followed from 1915 to 1938 was broken only by a shut down during 1926. Rocca used a modified Livermore furnace for reducing the ore when the first operations were begun, but it did not operate very successfully so in 1918, a 4 by 56-ft. rotary furnace was installed. This was the second successful plant using the rotary furnace, installed in California. Operations under Rocca continued to 1924, at which time Balch and Gould operated for a year. After a year of idleness, production on the property resumed in 1927 under the supervision of Cavagnaro and Schor, lessees at the time. Cavagnaro and Schor purchased the property sometime later, and they have held it since. The

FIG. 25. Power shovel in open cut at Cloverdale Mine, Sonoma County; contorted chert at right.
Photo by Walter W. Bradley.

last operator, G. H. Burr, leased the mine late in 1937, and was active through part of 1938. The mine is now idle.

General Geology. The geology at the Cloverdale mine is complicated by numerous faults and cross-fractures which give the mineralized area an extremely irregular appearance. The ore in general is found in a highly brecciated Franciscan radiolarian chert, near the contact

of chert and Franciscan sandstone strata. The faults, as indicated by a heavy attrition fault-gouge on the hangingwall, have a general northwest-southeast trend, and dip to the northeast. The gouge-covered hangingwall is crumpled and distorted, thus giving evidence of post mineral movement in the region. Mineralization is heaviest directly under the fault gouge, and the orebodies grade off into the footwall.

Cinnabar has been deposited in thin beds of chert between walls of shale. The ore mineral generally occurs as small fracture fillings or as paint on fracture faces. There has been no dissemination of cinnabar through the chert country rock, and this fact was a contributing influence to the metallurgical plan of treatment used unsuccessfully by Burr.

Mine and Plant. The underground workings at the Cloverdale mine are not very extensive, as the recent practice has been the open pit method of mining. G. E. Burr, when first operating, used a power shovel in the pits and transported the ore down to the plant in trucks. Mining operations were centered on top of a ridge. The rotary furnace plant is located near Big Sulphur Creek at a 1200 ft. lower elevation. An old gravity tramway from the open pits to the plant has been discarded.

Burr did not operate the rotary furnace on the property after the first few months. The old plant consists of a 4 ft. by 56 ft. Gould rotary furnace followed by an old condensing system with inclined tile pipes, and a series of wooden settling tanks. A concentrating plant was constructed at the scene of mining operations near the open pits. Burr mined the ore with power shovels and trucked it to the concentration plant where cinnabar was separated from chert gangue by mechanical scrubbers and a flotation unit. The concentrate was retorted.

Bibliography: State Mineralogist Reports XIV, p. 344; XVII, p. 250; XXII, p. 356. Bulletins 27, p. 98; 78, p. 183.

CULVER-BAER MINE

Location. M. D. M., T. 11 N., R. 9 W., SW¼ Sec. 23, about 20 miles southeast of Cloverdale, and about six miles from the Cloverdale mine.

Ownership. Culver-Baer Mining Company, Cloverdale, California. C. E. Humbert, president. C. A. Baumeister, lessee.

Production History. 1874-1880, 1900-1908, 1919-1911, 1915-1919, 1931-1932, 1934-—.

This mine was first noted as early as 1872, and production began in 1874. During the first period of production the ore was treated in retorts, and 8338 flasks were produced by 1880. The mine was then idle until it was reopened in 1900 by the Culver-Baer Mining Company, headed by G. B. Baer. Production was continuous under this company until 1908. A 16-ton Knox-Osborne coarse-ore furnace and a 24-ton Scott fine-ore furnace were used to treat the ore. In 1909, the property was purchased by the present owners, who did not start operations until in 1915. At that time the mine was reopened, and the furnaces reconditioned. Production was continuous until 1919, when the decreasing price of quicksilver forced a shut down. The ensuing period of idleness lasted until 1931, when H. C. Davey leased the mine. He operated only two years, and then gave up his lease. Recent work,

under the supervision of C. A. Baumeister, lessee, has been through two shallow adits in the upper part of the property near The Geysers road.

General Geology. The Culver-Baer ore zone is characterized by a silicified sandstone ledge which is traceable on the surface for about one mile. Veins in this ledge carry cinnabar, metacinnabar, and native quicksilver in a quartz and calcite gangue.

Mine and Plant. The mine has been developed by adits, drifts, and raises. There has been but little work done underground in recent years. There is no furnace on the property, and the ore that is mined is being treated in two "D" retorts.

Bibliography: State Mineralogist Reports XIV, p. 345; XVII, p. 252; XXII, p. 356. Bulletins 27, p. 102; 78, p. 185.

DOUBLE STAR PROSPECT

(See under OTHER COUNTIES AND MINES, page 476.)

ESPERANZA MINE (Formerly Bright Hope mine)

Location. T. 11 N., R. 9 W., SE¼ Sec. 10, between the Cloverdale and Culver-Baer mines, about 15 miles east from Cloverdale.

Ownership. James G. Cortelyou, Cloverdale, California.

Production History. 1917-1918, 1931-?-1939.

This property was first operated in 1917 when a few flasks were produced with a small retort. After some work in 1918, the mine was temporarily abandoned and remained idle until 1931. At this time the owner, Dr. G. T. Pomeroy, reopened the mine. He operated very sporadically through 1932, and then leased to Copps and Thompson. The present owner purchased the property in 1934, and has worked the mine at intervals. During 1938, Roy A. Meade operated the mine, producing a few flasks in a retort. At the present time (1939), Charles Crawford and J. P. Reisinger VI, are operating the mine.

General Geology. The ore deposit at the Esperanza mine occurs near the contact of serpentine and Franciscan sandstone. Cinnabar has been deposited along the contact, and as impregnation of the sandstone footwall.

Bibliography: State Mineralogist Reports XIV, p. 343; Chapt. rep. bien. per., 1913-1914, p. 171. Bulletin 78, p. 186.

EUREKA MINE (Originally Flagstaff mine)

Location. M. D. M., T. 11 N., R. 8 W., Sec. 32, about 20 miles northeast from Healdsburg, adjoining the Socrates mine on the northwest.

Ownership. Formerly owned by the Eureka Quicksilver Mining Company, now dissolved. Mine now abandoned.

Production History. 1904, 1916.

A few flasks of quicksilver were produced in 1904, and again in 1916, with a retort. In 1919, the operating company dissolved and the mine was abandoned.

Bibliography: State Mineralogist Reports XI, p. 65; XIV, p. 346. Bulletins 27, p. 106; 78, p. 187.

GREAT EASTERN MINE (Including MOUNT JACKSON MINE)

Location. M. D. M., T. 8 N., R. 10 W., Sec. 16. The Great Eastern mine and the adjoining Mount Jackson mine are located in an outlying

district of the county, away from the main producing belt which is the northwestern extension of the Mayacmas district. The mines are about 4 miles northeast from the town of Guerneville, in west-central Sonoma County.

Ownership. Great Eastern mine: Great Eastern Quicksilver Mining Company. George Roeth, Oakland, California, president. Mount Jackson mine: Last reported owner was J. A. Meacham, Guerneville, California.

Production History. 1875-1906, 1915-1919; 1935, 1937-1939 (Mount Jackson only).

These two mines are discussed under a single heading because there has never been any reduction equipment on the Mount Jackson property; consequently, all the ore mined has been handled through Great Eastern levels, and treated in the Great Eastern furnaces.

In 1875, production commenced at the Great Eastern mine and continued unbroken to the close of 1906. Ore was taken, during the last few years of this period, from the Mount Jackson property only, which was held under lease by the Great Eastern Quicksilver Mining Company.

From 1906 to 1915, the properties were idle; but late in 1915 activity resumed and production began shortly after. Ore was reduced in two Scott furnaces until the close of the World War. At this time (1919), the mine was closed and has not produced since.

Total recorded production for the Mount Jackson and Great Eastern mines amounts to 40,690 flasks.

General Geology. The Great Eastern and Mount Jackson orebodies are situated in a region of serpentine and Franciscan sandstone. At the contact of these rocks is a ledge of highly opalized rock, commonly known as "quicksilver rock." The ledge strikes N. 70° W., and dips 50° to 60° NE. Ore occurrences are in a soft decomposed material within the ledge matter, and cinnabar is generally found here in numerous seams and cross-seams with a quartz gangue. Mineralization probably followed the serpentine intrusion along the plane of weakness, developed at the sandstone contact.

Bibliography: State Mineralogist Reports I, p. 27; IV, p. 341; V, p. 95; VI, p. 72; VIII, p. 633; XI, p. 460; XII, p. 371; XIII, p. 602; XIV, p. 347; XXII, p. 356; Chapter rep. bien. period, 1913-1914, p. 175. Bulletins 27, p. 106; 78, p. 187. U. S. G. S. Mon. XIII, pp. 362-364. Min. Res. West of Rocky Mts., 1875, p. 14; 1876, p. 20.

GREAT NORTHERN GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

HURLEY PROSPECT

(See under OTHER COUNTIES AND MINES, page 476.)

KISSACK MINE (Also referred to as Amazon; formerly Squaw and Big Chief claims)

Location. M. D. M., T. 11 N., R. 9 W., Sec. 4, adjoining the Cloverdale mine, 12 miles east of Cloverdale.

Ownership. L. D. Kissack, Cloverdale.

Production History. 1930, 1932, 1936.

Originally this property consisted of the Squaw and Big Chief Claims. Bradley * in 1918, reported that a small amount of high grade ore had been sorted out of material from a short tunnel and incline, and that only assessment work was done. The Big Chief claim was subsequently abandoned. During 1930, '32, and '36, Kissack reported a very small production from the property under the name of the Kissack or Amazon mine.

General Geology. The ore is similar to that of the Cloverdale mine.

Bibliography: State Mineralogists Reports XIV, p. 351; XVII, p. 252; Chapter rep. bien. period, 1913-1914, p. 179. *Bulletin 78, p. 196.

LOOKOUT GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

LUCKY STONE GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

MARICOMA PROSPECT

(See under OTHER COUNTIES AND MINES, page 476.)

MOUNT JACKSON MINE (See under Great Eastern mine)

NAPA PROSPECT

(See under OTHER COUNTIES AND MINES, page 476.)

NEW SONOMA MINE (Formerly Sonoma Consolidated Group, including Crown Point and Hope)

Location. M. D. M., T. 10 N., R. 8 W., Secs. 4 and 5, about 16 miles northeast of Healdsburg, and about 2 miles north of Pine Flat.

Production History. 1904, 1917.

Records of early production from this property are vague. In 1904, under the Crown Point Mining Company, a small yield was realized. In 1910, the Culver-Baer Mining Company purchased the property and transferred some of the reduction equipment to the Culver-Baer mine. The land was not patented, and so in 1917, T. Gale Perkins relocated the claims, set up a D retort, and operated during the remainder of that year. No production has been made since that time.

General Geology. The native quicksilver, which was formerly present in such abundant quantities, occurs in a black, brecciated mass in serpentine and Franciscan strata.

Bibliography: State Mineralogist Reports XIII, p. 603; XIV, p. 349; XXII, p. 356. Bulletins 27, p. 115; 78, p. 192.

OCCIDENTAL AND HEALDSBURG GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

OLD CHAPMAN PROSPECT

(See under OTHER COUNTIES AND MINES, page 476.)

PACIFIC GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

RATTLESNAKE MINE

Location. M. D. M., T. 11 N., R. 8 W., Sec. 31, on the road between the Culver-Baer mine and Pine Flat.

Ownership. Last reported owners (1918), G. W. Wheeler and Frank G. Kiessig, Pine Flat.

Production History. 1875, 1916-1917.

This mine is credited with a production of 65 flasks in 1875, entirely from native quicksilver with which was associated an oily bitumen. The mine was idle and inaccessible for many years until reopened by Wheeler and Kiessig in 1916. A few flasks of quicksilver were recovered by washing and retorting. During 1917, a lessee recovered a small amount of metal. The mine has been idle since.

General Geology. The country rock consists of altered sedimentaries and serpentine. The native metal occurs in a black brecciated mass and gouge.

Bibliography: State Mineralogist Reports XIII, p. 603; XIV, p. 349; XXII, p. 356; Chapter rep. bien. period, 1913-1914, p. 177. Bulletins 27, p. 115; 78, p. 192. U. S. G. S. Mon. XIII, p. 377; Min. Res. W. of Rocky Mts., 1874, p. 37; 1875, pp. 14, 176; Trans. A. I. M. E. Vol. III, p. 273.

SKAGGS MINE

Location. M. D. M., T. 10 N., R. 11 W., portions of Secs. 23, 24, 25, and 26; and T. 10 N., R. 10 W., portions of Secs. 19 and 30. This mine is at Skaggs Springs, about 9 miles by road west of Geyserville.

Ownership. Leo Curtis, Skaggs Springs, California.

Production History. 1931, 1934.

Quicksilver ore was first noted as occurring in commercial quantities on this property in 1925. No production was made, however, until 1931. Leo Curtis, the owner, leased the property to various interests during the following years, and in 1934, he took over operations himself. After 90 days of production in which he recovered a total of 42 flasks, Curtis ceased operations. The property was leased by C. N. Schuette the following year, and some development work was done, but no ore was produced. There has been no production made during the past few years. The property was leased to A. C. Kroeger and the General Utility Corp. in 1939.

General Geology. The quicksilver deposits at Skaggs Springs are found within a country rock of coarse-grained, greenish gray sandstone. At first glance the rock appears to be barren, but a closer inspection reveals the presence of very finely disseminated metacinnabar.

In the vicinity of some thermal springs, just north of the mine workings, such minerals as realgar, orpiment, and the hydro-carbon curtisite, can be found. Metacinnabar is found here, associated with these minerals, but apparently not in commercial quantity. To the south of the main shaft, an undeveloped deposit of cinnabar has been noted.

Mine and Plant. The mine is developed by an inclined shaft to a depth of 100 ft., with a series of drifts and crosscuts leaving this shaft at various levels. The shaft is now caved and partially flooded. The

reduction equipment on the property consists of a 10-pipe Johnson-McKay retort, oil fired with two burners.

SOCRATES MINE (Formerly Pioneer mine)

Location. M. D. M., T. 10 N., R. 8 W., Secs. 4 and 5; and T. 11 N., R. 8 W., Secs. 32 and 33, about 6 miles southeast from the Geysers, on the divide between Big Sulphur and Little Sulphur Creeks.

Ownership. Interest in the mine is held by a corporation. R. R. Vought, chairman; Monadnock Building, San Francisco, California.

Production History. 1861-?, 1901-1906, 1908-1910, 1917-1918, 1932.

The Socrates mine was first noted in 1861, and produced a reported total of 1000 flasks by the end of the century. In 1901, the mine was reopened and operated for a 5-year period, at the end of which time a forest fire destroyed the plant, forcing a shut down. A bond on the property was then taken by the Socrates Development Company and operations resumed in 1908. The mine was again closed down in 1911, and remained idle until 1916, when the U. S. Development Corporation leased the property and constructed a 40-ton Scott furnace. Production began again in 1917, and lasted for two years. A very few flasks were recovered in 1932. C. F. Degner of Healdsburg, during 1939, filed location on 8 claims known as the Acme Group on abandoned Socrates property; no production has yet been made.

General Geology. The Socrates orebody occurs at the contact of serpentine and Franciscan sandstone. The intrusive serpentine has been highly silicified near the contact and forms a sharp ridge with the sandstone on the slope. Ore deposition apparently followed the silicification period, as the harder serpentine has not been impregnated with cinnabar.

A great percentage of the metal extracted was in the form of native quicksilver, which forms as small globules in compact portions of the rock. At lower levels, cinnabar is quite common, occurring disseminated and as small stringers.

Bibliography: State Mineralogist Reports XIV, p. 350; XXII, p. 356. Bulletins 27, p. 115; 78, p. 193.

WALKER MINE (Also known as Contact mine; formerly Queen Group of Crown Point Company)

Location. M. D. M., T. 10 N., R. 8 W., Sec. 5, about 1 mile west of Pine Flat.

Ownership. H. G. Walker and associates, Reno, Nevada.

Production History. 1932-1936, 1938-—.

The mine first produced in 1932 and in a superficial way continued through 1936, under the operation of J. E. Grover. In October, 1937, he sold the property to H. G. Walker who reported a small production during 1938 from a Wyatt furnace. The furnace consists essentially of two inclined tubes, 22½ ft. long and about a foot in diameter. A baffle is placed in each tube near the upper end above a slit which extends along the tube to within 6 feet of the lower end. Both tubes are filled with ore crushed to 1½ in. and roasted for 12 hours. The burned ore or calcine is drawn off the bottom. The capacity of the furnace is 3 to 4 tons per 12 hours. A rotary furnace is being installed (January, 1940).

General Geology. The ore occurs in the form of cinnabar and some native quicksilver along a serpentine-sandstone contact.

WALKER PROSPECT

(See under OTHER COUNTIES AND MINES, page 476.)

WALL SPRING PROSPECT

(See under OTHER COUNTIES AND MINES, page 476.)

FIG. 26. Wyatt quicksilver furnace at Walker (Contact) Mine, Pine Flat, Sonoma County.

Photo by Walter W. Bradley.

STANISLAUS COUNTY

In the western portion of Stanislaus County, several occurrences of cinnabar have been noted; two of these deposits have proven to be of limited commercial extent. The most productive is the area included in the properties of the Phoenix and Adobe Valley mines, near the

junction of Stanislaus, San Joaquin, Alameda, and Santa Clara counties.

About 10 miles southeast from this area is the second productive region. This is at the headwaters of Orestimba Creek, where the Orestimba and International mines are located.

ADOBE VALLEY MINE (Formerly Stanislaus)

Location. M. D. M., T. 6 S., R. 5 E., Secs. 23 and 24, about 2 miles east of the Phoenix mine, and 21 miles west of Patterson.

Production History. 1884-1888.

This mine was opened up in 1884, and was operated for a period of 4 years. In 1888, the mine was abandoned and has remained idle to date.

General Geology. The ore on this property occurs as cinnabar in fracture zones, cutting across a gray Franciscan sandstone. The country rock on either side of the fractures has been slightly impregnated by cinnabar.

Bibliography: State Mineralogist Reports X, p. 680; XIV, p. 632; XXI, p. 216; Chapt. rep. bien. period, 1913-1914, p. 206. Bulletins 27, p. 189; 78, p. 197.

CROCKER-WINSHIP PROSPECT

(See under Other Counties and Mines, page 476.)

GIGAX CLAIMS

(See under Other Counties and Mines, page 476.)

INTERNATIONAL MINE

Location. M. D. M., T. 8 S., R. 6 E., Sec. 3, on the south fork of Orestimba Creek, about a mile south of the Orestimba mine.

Production History. Pre-1880 (small).

A small amount of retorted ore from this property yielded a few flasks of quicksilver some time prior to 1880. There has been no further activity recorded.

Bibliography: State Mineralogist Report X, p. 681. Bulletin 78, p. 198.

NEWHALL MINE

(See under Other Counties and Mines, page 476.)

ORESTIMBA MINE (Also Palo Alto mine)

Location. M. D. M., T. 7 S., R. 6 E., Sec. 28, about 25 miles southwest from Crows Landing. The mine is accessible by a poor dirt road for the first 20 miles from Crows Landing, followed by 5 miles of trail.

Ownership. Last reported owner (1925), Orestimba Mining Company, H. A. Wilder, Los Gatos.

Production History. Pre-1900 (small), 1917.

This property was opened some time prior to 1900, by the Hazard Quicksilver Mining Company. After years of idleness, the mine was reopened in 1917 by the Orestimba Mining Company. A 12-pipe retort was installed and a small production was reported under the name of the Palo Alto Mining Association. The following year, a small amount of development was carried on, but there was no production. The mine has been idle since 1918.

General Geology. There is very little published data on this property; and practically no geology of the property has been mapped. Forstner[1] reports that the country rock is apparently silicified shale.

Bibliography: State Mineralogist Reports X, p. 60; XXI, p. 216. Bulletin 27, p. 189.

PHOENIX MINES (Formerly Hayward mine. Includes Summit, Grayson and Orestimba groups; also referred to as Hayward)

Location. M. D. M., T. 6 S., R. 5 E., Secs. 20, 21, 28, and 29 (Summit-Grayson), and Secs. 25, 35, and 36 (Orestimba); about 39 miles, by good road, southeast from Livermore.

Production History. 1870-?, 1901-1903, 1913-1916.

The Phoenix mines first produced in the seventies, when the properties were operated by Mr. Waterford. Alvinza Hayward purchased the property in 1901, and installed a 50-ton Scott furnace. After two years of production, activity ceased and the mines remained idle until 1915. At that time they were reopened by the Phoenix Quicksilver Mining Company, and production continued through 1916. Operations then ceased, and the mines have remained idle to date.

General Geology. The country rocks of the Phoenix property consist of serpentine and Franciscan sandstone. Striking through these rocks are three zones of mineralization which carry veins of cinnabar in a calcite gangue.

Bibliography: State Mineralogist Reports I, p. 27; XIII, p. 603; XXI, p. 216. Bulletins 27, p. 188; 78, p. 198.

TRINITY COUNTY

The known deposits of quicksilver in Trinity County occur in the northeastern part, between Crow Creek and the North Fork of the East Fork of Trinity River. The principal producer in this district is the Altoona mine, which has been operating at intervals for the past 63 years. Nearby is the Integral mine which has not proven to be as economically important as the Altoona.

A total yield of 32,540 flasks is recorded for the county to the end of 1938, with almost the entire amount having come from the Altoona mine.

ALTOONA MINE

Location. M. D. M., T. 38 N., R. 6 W., Sec. 22, about 15 miles northeast of Carrville and about 16 miles northwest of Castella.

Ownership. Altoona Quicksilver Mining Company, J. Frowenfeld, president, 2280 Pacific Ave., San Francisco, California.

Production History. Pre-1875, 1875-1880, 1890, 1895-1912, 1916-1918, 1920-1921, 1929-1937, 1939.

The deposits of the Altoona mine were first worked by placer methods in the stream gravels below the outcrops. The property was purchased by the present owners in 1875. During the first five years of this company's operation, an average of 1500 flasks per annum was recovered by retorting high grade ore. Litigation in 1880 forced the owners to close the mine, and, with the exception of a small production made in 1890, the property remained idle until 1895. At that time the

[1] Forstner, Wm., op. cit., p. 189.

mine was reopened, a Knox-Osborne furnace was constructed, and production started which was continuous until 1902. A fire then partially destroyed the plant, with consequent dropping off of production, and final cessation of all operations in 1912. No great interest was taken in the mine during the World War, and the only production recorded was the result of cleaning-up operations carried on by lessees. A few more flasks were recovered by lessees in 1920 and 1921, after which time the mine remained idle for a period of seven years. In 1929, the owners reopened the mine, and have produced some quicksilver every year to date. The property is now under lease to C. W. Erickson, Castella.

General Geology. The country rocks surrounding the Altoona mine are serpentine and altered feldspar porphyry. The mineralized zone, some 400 ft. long and extending to a depth of over 600 ft. is a serpentine-porphyry contact. The hangingwall is the porphyry, and the footwall is serpentine.

Mine and Plant. The Altoona has been mined to a depth of over 600 ft., through a 450-ft. vertical shaft and a 152-ft. winze. Development includes 7 levels, with drifts and crosscuts extending 1600 ft. in a northwest-southeast direction, and over 1100 ft. in a northeast-southwest direction. Reduction equipment consists of a 40-ton rotary furnace, and a stainless steel condensing unit with 11-in. vertical pipes; a 4-disk concentrator was recently installed by Erickson (see Aetna mine for more detailed description of the device).

The mine is not operated during the winter because of severe weather conditions.

Bibliography: State Mineralogist Reports I, p. 27; IV, p. 338; XII, p. 371; XIII, p. 603; XIV, p. 923; XXII, p. 65; XXVII, p. 63. Bulletins 27, p. 192; 78, p. 200. U. S. G. S. Mon. XIII, p. 366; Min. Res. W. of Rocky Mts., 1875, p. 20; 1876, p 19.

ANNA BELL CINNABAR MINE

(See under Other Counties and Mines, page 476.)

CARR PROSPECT

(See under Other Counties and Mines, page 476.)

INTEGRAL MINE

Location. M. D. M., T. 38 N., R. 6 W., Secs. 15, 22, and 23, about 1 mile northwest of the Altoona mine, on the west side of Crow Creek.

Ownership. Estate of William J. Simpson, New York City.

Production History. 1902-1903.

The Integral mine was known as a producer during 1902 and 1903, when it was operated by the Integral Quicksilver Mining Company. There has been no recorded production from the property since that time. Zack Anderson, lessee, of Middletown, Lake County, is doing some work at the present time.

General Geology. The geology of the Integral mine is similar in many respects to that of the Altoona mine. Ore is found in lenses of altered porphyry which is surrounded by serpentine.

Bibliography: State Mineralogist Reports XII, p. 372; XIII, p. 604; XIV, p. 924; XXII, p. 66. Bulletins 27, p. 193; 78, p. 202.

OVERLAND GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

TRINITY GROUP

(See under OTHER COUNTIES AND MINES, page 476.)

TUOLUMNE COUNTY

(See under OTHER COUNTIES AND MINES, page 476.)

YOLO COUNTY

The quicksilver deposits of Yolo County are in the Knoxville district which extends from Napa and Lake Counties into the northwestern corner of Yolo County. There are only two mines of any importance in this region, none of which has reported other than a small production for a number of years. The total production from the county is recorded at 9746 flasks to the end of 1938.

HARRISON MINE (Formerly Harrison, New England, Ruby and January mines, respectively)

Location. M. D. M., T. 12 N., R. 5 W., Secs. 26 and 35, on the Yolo-Napa County border, about 8 miles southwest from Rumsey.

Ownership. Verne and Vince Harrison, Lower Lake, California.

Production History. Pre-1900 (small), 1917, 1937-1939.

This mine, originally known as the Harrison, was a small producer some time prior to 1900, and then lapsed into a long period of idleness. Interest in the property rose during the War years, with a small production reported in 1917, and a concentrating mill erected the following year. There is no record of any production ever having come from this mill. Since 1937, the mine has been operating again under the name of the Harrison mine, by J. B. Abercombie of Middletown, who reported a small production from retorted ore.

General Geology. The ore zone on the Harrison property is limited to a belt of black opaline rock 8 to 15 ft. wide, which strikes across a mass of serpentine. Cinnabar in this siliceous belt has been deposited as small seams.

Bibliography: State Mineralogist Report XIV, p. 369. Bulletins 27, p. 117; 78, p. 204.

REED MINE (Originally California)

Location. M. D. M., T. 12 N., R. 5 W., Secs. 23, 24, 25, and 26, about one mile north of the January mine and about 8 miles south of west from Rumsey.

Ownership. George Newhall, Jr., San Francisco, California.

Production History. 1873-1880, 1913, 1915, 1917, 1939.

The Reed mine was once an important property, having produced a total of 9,648 flasks within the seven-year period, 1873-1880. The bricks and mortar of the old plant, which had previously been destroyed by fire, were treated in retorts during the War years, and a few flasks were consequently recovered. The mine has recently been leased by the Bradley Mining Company, San Francisco (1939), with a view towards reopening and developing the old property.

General Geology. At the Reed mine, as at the Knoxville mine, some three miles to the southwest, the ore is found in opaline material at the contact of serpentine and Jurassic Knoxville sediments.

Bibliography: State Mineralogist Reports I, p. 27; V, p. 96; XI, p. 68; XIII, p. 604; XIV, p. 369. Bulletins 27, p. 117; 78, p. 205.

OTHER COUNTIES AND MINES

Of the 40 counties listed in this report, there are 13 in which quicksilver has been noted, but in insufficient amounts for commercial development. In the remaining counties which have or do produce quicksilver, are listed also, a number of mines and prospects from which there has been no activity, in most instances, for over 20 years; in any case the record of production has been negligible or nothing.

No one can foresee the discovery of a new deposit, the reopening of an old mine, or the development of a prospect into a mine. For this reason, as well as a matter of record, the names of these other counties and mines are herewith grouped together. Anyone desiring additional information is referred to Walter W. Bradley's report on The Quicksilver Resources of California, written in 1918 (California State Min. Bur. Bull. 78, 1918).

Quicksilver in non-commercial amounts has been noted in the following counties: Alameda, Calaveras, Glenn, Humboldt, Los Angeles, Marin, Mariposa, Mono, Nevada, San Francisco, San Mateo, Shasta (Clover Creek mine), and Tuolumne.

The following mines and prospects have a record of little or no production and have been inactive for many years:

KERN COUNTY—Tardy claims; KINGS COUNTY—Fairview group; LAKE COUNTY—Hays mine, Maypole prospect, Middletown prospect, Red Rock and Silver Rock claims, Rich Hill prospect, Shamrock prospect, and White Elephant prospect; MONTEREY COUNTY—Dutro mine, and Monte Cristo group; NAPA COUNTY—Aetna Extension claims, Calistoga Hot Springs, Mountain mine, Northern Light prospect, Palisades Silver mine, and Philadelphia claims; SAN BENITO COUNTY—Bonanza group, Cannon mine, Don Juan and Don Miguel mines, Lone Star mine, and Niesen group; SAN BERNARDINO COUNTY—Desert Mercury group (see State Min. Rept. XXVII, p. 339, 1931), Idria Quicksilver group (see State Min. Rept. XXVII, p. 339, 1931), and Mercury group; SAN LUIS OBISPO COUNTY—Claus group, Cypress Mt. group, Elizabeth and Winona group, Kismet group, Marquart Ranch prospect, North Star mine, Sunset View mine, Vulture mine, Warren ranch, William Tell mine, and Wittenberg mine; SANTA BARBARA COUNTY—Mercur claim, and Steward mine; SANTA CLARA COUNTY—Bernal mine, Bowie prospect, Brainard prospect, Costello mine, Santa Teresa mine, and Wright mine; SOLANO COUNTY—Brownlie mine; SONOMA COUNTY—Almaden, Incandescent and Tunnel Site groups, Boston group, Double Star prospect, Great Northern group, Hurley prospect, Lookout group, Lucky Stone group, Maricoma prospect, Napa prospect, Occidental and Healdsburg group, Old Chapman prospect, Pacific group, Walker prospect, and Wall Street prospect; STANISLAUS COUNTY—Crocker-Winship prospect, Gigax claims, and Newhall mine; TRINITY COUNTY—Anna Bell Cinnabar mine (see State Min. Rept. XXII, p. 66, 1926), Carr prospect, Overland group, and Trinity group.

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SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

10—80300

SULPHATE MINERALS AT THE LEVIATHAN SULPHUR MINE, ALPINE COUNTY, CALIFORNIA

By GEO. L. GARY, Mineral Technologist

At the Leviathan sulphur mine, about seven miles east of Markleeville, the county seat of Alpine County, five exceptionally interesting sulphate minerals have been recently identified. These are secondary minerals formed by the oxidizing action of surface water upon certain sulphide or sulphur-bearing minerals.

During the 60's this property, which now consists of 90 unpatented claims, covering an area of 1800 acres, was operated as a copper mine on a body of high-grade ore.[1] In recent years large bodies of low-grade and considerable amounts of high-grade sulphur ore have been developed. The Calpine Corporation of Los Angeles, owners of the property, have a mill at the mine and an experimental plant for recovery of the sulphur from the low-grade ore by steam liquation.

On September 30, 1939, Walter W. Bradley, State Mineralogist, J. C. O'Brien, Mining Engineer, Dr. Adolf Pabst, Associate Professor of Mineralogy, University of California and the writer visited the mine, inspected the workings and obtained specimens through the courtesy of the management. It is from this material that the following minerals were determined.

CHALCANTHITE

Chalcanthite, $CuSO_4.5H_2O$, a hydrous cupric sulphate, formed through the oxidation of copper sulphides and deposited from mine waters was identified by its chemical and physical properties. It occurs in groups of brittle flattened crystals; also in massive and stalactitic forms. This mineral in considerable amounts was noted in most of the mine openings. It also occurs in small veinlets in tuff breccia impregnated with sulphur. The combination of the Berlin-blue color of this mineral with the yellow sulphur as a background forms a beautiful underground picture.

IRON-COPPER CHALCANTHITE

Iron-copper chalcanthite, $FeO.CuO.2SO_3.10H_2O$,[2] a hydrous iron-copper sulphate, was identified by its chemical and optical properties. It occurs in pale-blue massive forms in several places in the lower adit of the mine.

HALOTRICHITE

Halotrichite, $FeSO_4.Al_2(SO_4)_3.22H_2O$, a hydrous iron-aluminum sulphate, was identified by its chemical and physical properties. It occurs as white and yellowish silky fibrous growths, four to five inches long, grouped together in tuft-like masses in several places in the lower adit of the mine.

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[1] California Div. Mines, State Mineralogist's Report XXVII, p. 491, 1931.

[2] Esper S. Larsen and Harry Berman, The microscopic determination of the nonopaque minerals: U. S. Geol. Survey Bull. 848, p. 156, 1934.

MELANTERITE

Melanterite, $FeSO_4.7H_2O$, a hydrous ferrous sulphate, was identified by its chemical and optical properties. It occurs as white brittle massive crusts and stalactites of various shades of green in all the mine openings. This mineral results from the decomposition of the pyrite present in the mine. It becomes yellowish on exposure.

RÖMERITE

Römerite, $FeSO_4Fe_2(SO_4)_3.14H_2O$, a very rare hydrous iron sulphate was identified by its optical properties, obtained from the examination of crushed fragments. Biaxial negative. $B = 1.571$. Birefringence .059. Strong crossed dispersion. Abnormal interference colors. It occurs in brittle chestnut-brown tabular triclinic crystals in masses and implanted on melanterite stalactites in one of the stopes of the lower adit of the mine. This mineral has only been noted twice before in California; from Island Mountain in Trinity County,[3] and in the Calico Hills near Borate, about six miles northeast of Yermo, San Bernardino County.[4]

The above minerals are on display in the museum of the State Division of Mines in the Ferry Building, San Francisco.

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[3] Landon, Robert E., Roemerite from California: Am. Mineralogist, vol. 12, pp. 279-283, 1927.

[4] Foshag, William F., Krausite, a new sulfate from California: Am. Mineralogist, vol. 16, pp. 352-360, 1931.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel

There have been no changes in personnel to be noted, during the past three months.

New Publications

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, January 1939, being Chapter 1 of State Mineralogist's Report XXXV. This chapter contains: "Mineral Resources of San Diego County," accompanied by a map showing the locations of mining claims in the county; "Geology and Oil Possibilities of Southwestern San Diego County"; "The Prospect for 'Minor Metals' and Nonmetallic Minerals"; "The Right to Mine"; also the estimate of the statistical branch on the 1938 Mineral Production of California; accessions to the mineral exhibit and to the library of the Division of Mines.

COMMERCIAL MINERAL NOTES (Nos. 196-198 incl.) August, September, October, 1939, respectively. These 'Notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to five pages in recent months.

Mail and Files

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum

HENRY H. SYMONS, Statistician and Curator

STATISTICS

COMMERCIAL MINERALS OF CALIFORNIA

Much of the wealth and power of a nation depends on its mineral resources. There is not an industry nor a human throughout the world, even the most primitive, that does not directly depend on minerals for its existence. As civilization advances life becomes more complex; and to carry on, more minerals are required. This means additional mineral substances are added to the commercial list and new uses are found for others. Also many minerals not now used may have potential values and become commercial when production costs are reduced, larger deposits found, or existing deposits of materials now being used become depleted, not including new discoveries.

Few people think that agriculture depends on the mineral industry in any way, but let's see. The machinery used on the farm is made of metals, the commercial fertilizers are made up of a mixture of minerals, the soil conditioners are minerals. Many of the sprays and insecticides are mineral salts or manufactured from minerals; even the fuel used by the tractor and to run pumps, etc., come under this heading. Hundreds of other things used on the farm could not exist if certain minerals were not available.

The Division of Mines is now preparing abstracts and bibliographies of each economic mineral substance produced in California, from our publications and such outside sources as are deemed necessary so as to help people interested in a particular substance and have the data in one place. These abstracts will be printed and sold as demand justifies.

Still, most people know little if anything about these minerals, including those who own deposits and those who try to sell them. To commercialize a deposit, the better one's knowledge is of the material to be handled, the better is his chance for success. Not only is it necessary to know how to mine the material, but the miner should know the grades suitable for his buyer, how to maintain the grades, what other material (waste) not shipped may be suitable for other uses, and above all to be a salesman. He must know something about the processing of, manufacture, and finished product. Take for example the miner of muscovite mica: scrap mica is worth \$5.00 to \$7.50 a ton at the mine if favorably located, ground and conditioned for market, 20 mesh \$14.00 to \$17.00 a ton, 300 mesh \$15.00 to \$20.00 a ton, while sheet mica in perfect sheets 1″ x 1″ is 5¢ a pound, 1½″ x 2″ 25¢ a pound, and 8″ x 10″ sheet \$7.50 a pound, with intermediate sizes proportional.

Large books of mica that are not perfect are cut to size, wavy parts and imperfect material going to scrap; also, off color material is thrown to scrap. The miner of commercial minerals or minor metals which are highly competitive, is in quite a different position from the gold miner who sends his bullion to the mint and receives $35.00 a fine ounce, or his ore or concentrate to the smelter, paying for reduction and freight charges, and is paid $35.00 an ounce for gold contained, or the miner of copper, lead or zinc who ships his ore or concentrate to the smelter and receives payment on New York quotation for the day received at smelter for recoverable metal—less reduction cost and shipping charges, etc.

Most minor metals and nonmetallic minerals are highly competitive, and therefore the miner should consider the following suggestions: Both the miner and the manufacturer of mineral products should know something of the geology of mineral deposits of the type of material they are handling. This will enable them to determine the extent of their deposits, where to look for additional ore, what method is most advantageous in mining, and, when their present deposit becomes depleted, where to look for a new deposit, and if there are any suitable for their purpose. Ore reserves are a very important thing to a manufacturer, as when he puts a product on the market he is expected to supply a uniform product over a long period of time, and constantly changing sources of crude materials means adjustments in manufacturing methods. Such changes are expensive.

What should the miner expect for his mineral product? There are many quotations printed that give what is being paid for metals, ores, and nonmetallics suitable, delivered under certain specifications to plants; but it must be remembered that these specifications usually are not for raw material as it comes from the earth, but crushed to a given mesh, with certain impurities removed. This means processing and reduces the amount received by the miner, as transportation and milling costs are subtracted from quotations. The amount, also the market requirements, may not justify a miner to install a mill on his property. Transportation is an important factor and often decides whether a deposit is commercial or not.

Often the owner of a piece of land claims things for his property that are not true, or expects more for it than is reasonable. Both are brought about by not having a complete knowledge of the material in his deposit. The condition here is usually the result of information given by the parties who do not know the commercial minerals industry. The misrepresentation of minerals hurts the mineral industry, as possible users often get disgusted and seek materials elsewhere for their product, and many deposits that should be in operation are idle.

California is extremely fortunate in the abundance of minerals to be found within its boundaries. There are over 400 different mineral species found in the state, 54 of which were first discovered here, and annually nearly 60 substances are commercially utilized, not segregating the several varieties of gems.

The accompanying chart, Commercial Minerals of California, indicates by substance and counties the location of various deposits and commercial status of each, by the following symbols:

COMMERCIAL MINERALS OF CALIFORNIA

▲ DEPOSITS PRODUCING COMMERCIAL AMOUNTS 1935-38 (NAMES & ADDRESSES NOTED IN DIRECTORY OF PRODUCERS OTHER THAN NATURAL GAS & PETROLEUM)

△ DEPOSITS OF SMALL PRODUCTION OR AS BY-PRODUCT IN MINING FOR OTHER MINERALS

X DEPOSITS OF KNOWN COMMERCIAL VALUE NOW IDLE

O DEPOSITS OF LITTLE OR UNKNOWN COMMERCIAL VALUE (NOTED IN REPORTS OF THE STATE MINERALOGIST)

⧗ PLANTS NOW IDLE OR UNDER CONSTRUCTION

	ALAMEDA	ALPINE	AMADOR	BUTTE	CALAVERAS	COLUSA	CONTRA COSTA	DEL NORTE	EL DORADO	FRESNO	GLENN	HUMBOLDT	IMPERIAL	INYO	KERN	KINGS	LAKE	LASSEN	LOS ANGELES	MADERA	MARIN	MARIPOSA	MENDOCINO	MERCED	MODOC	MONO	MONTEREY	NAPA	NEVADA	ORANGE	PLACER	PLUMAS	RIVERSIDE	SACRAMENTO	SAN BENITO	SAN BERNARDINO	SAN DIEGO	SAN FRANCISCO	SAN JOAQUIN	SAN LUIS OBISPO	SAN MATEO	SANTA BARBARA	SANTA CLARA	SANTA CRUZ	SHASTA	SIERRA	SISKIYOU	SOLANO	SONOMA	STANISLAUS	SUTTER	TEHAMA	TRINITY	TULARE	TUOLUMNE	VENTURA	YOLO	YUBA
FUELS																																																										
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NATURAL GAS				△						▲	△	△			▲	▲	O		▲				△				△			▲				△					▲	O	O	▲	O						▲		△	O		△		▲	△	O
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CADMIUM														O												O																			O													
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COBALT					O									O					O	O		O				O		O	O		O						O												O									
COPPER	X	O	△	△	△	O	O	O	△	X	O	X	△	△	△		O		△	X	O	△	O	O		△		△	△		△	▲	△			△	△			O					X	△	X		O			O	X	O	△			O
GOLD		△	▲	▲	▲	O		△	▲	△	O	▲	▲	▲	▲	O	O	△	▲	△		▲	O	▲	△	▲	△	▲	▲	△	▲	▲	▲	▲		▲	△	△	▲	△		O	△	△	▲	▲	▲		O	▲	O	▲	▲	△	▲	△	△	▲
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MANGANESE ORE	X		X	X	O		O				X	O	O	O			O		O		O		X	O			O	X	O		X	X	X		O	X			X	X			X		X		X		O	X		O	X	X	O			
MOLYBDENUM ORE		O			O									O					O	O						O	O				O	O				O	O								O		O						O	O		O		
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MAGNESIUM SALT	▲																																				▲				▲																	
POTASH																																				▲																						
SALT	▲			△		O							△	X	▲				▲		O				△	O	▲			△						▲	▲			O	▲		⧗		O			O										
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COMPILED BY CALIFORNIA STATE DIVISION OF MINES OCTOBER 1939

(▲) The solid black triangle is used where the county output justifies a more or less continuous operation.

(△) The open triangle indicates deposits where the market only justifies a limited annual production or other small output, also in cases where the mineral substance is derived as a by-product in mining, but is utilized commercially.

(X) The ''X'' is used in counties where at one time there were productions that were relatively large but for economic reason shut down, but could be opened and produce again.

(⧗) This symbol is used in the case of cement mills, brick and hollow building tile plants, and lime kilns, which are manufacturing plants for crude mineral substances and necessary to prepare the product for the market, to denote that the plants are down, or new ones under construction.

(◯) The circle is used to denote known deposits and occurrences of undetermined commercial status, but noted at one time or another in the publications of the State Mineralogist, from which this chart was compiled.

The names and addresses of all operators in counties marked with a triangle, either solid or hollow, with the exception of natural gas, petroleum and the smaller producers of metals, will be found in the directory of Bulletins 112, 114, 116 or 117 of the department.

The chart was compiled from statistical tabulation sheets for 1935 to 1938, inclusive. Reports of State Mineralogist and our bulletins and mineral abstracts are now being prepared.

All of our publications may be consulted and those in print purchased, at the library of the San Francisco headquarters' office, and branches in Sacramento, and Los Angeles office. They may also be consulted at practically all the county libraries throughout the state, libraries of most large cities, and many colleges and universities throughout the United States.

There are many books, reports and articles written on the marketing of metals and minerals. Most of them are good and contain much helpful information. As for marketing information, such books as the U. S. Bureau of Mines' ''Mineral Year Book,'' ''Marketing of Metals and Minerals,'' by Josiah Edward Spurr and Felix Edgar Wormser; ''Non-Metallic Minerals,'' by Raymond B. Ladoo; ''Industrial Minerals and Rock,'' Seeley W. Mudd Series, The American Institute of Mining and Metallurgical Engineers; ''Strategic Mineral Supplies,'' by G. A. Rouse, etc.; on geology, the reports of U. S. Geological Survey, various state reports, etc.; on Mining Methods, ore dressing and milling, the reports of the U. S. Bureau of Mines, etc. Articles published in technical periodicals and books by individuals cover all the above phases in detail, but are too numerous to name here.

The U. S. Bureau of Mines publishes a series of reports called, ''Information Circulars,'' which deal in all the above details on various commercial minerals, while others deal in the particular problems of certain operations. These are for free distribution by the Federal Bureau as long as in print.

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20937 RHODONITE, a manganese silicate. From Jack Fry ranch, near Tuolumne City, Tuolumne County, California.
Donor: H. Shaw. July, 1939.

20938 BARITE ($BaSO_4$), a barium sulphate. From near Hoopa, Humboldt County, California.
Donor: H. C. Chester. July, 1939.

20939 PITCHBLENDE concentrates, running 72.44% U_3O_8. From Wilberforce, Ontario, Canada.
Donor: Henry Mulryan, August, 1939.

20940 FLINT-CLAY ("Sierra" bed) being mined by Gladding McBean & Company for refractory uses. Locality: Claymont ("Goat Ranch") Mine, Santa Ana Canyon, Orange County, California.
Donor: Henry Mulryan, August, 1939.

20941 BARITE $BaSO_4$ barium sulphate from Hartsel, Colorado.
Donor: Joseph J. Cole, Jr. August, 1939.

20942 ORTHOCLASE (crystals) from Florrissant, Colorado.
Donor: Joseph J. Cole, Jr. August, 1939.

20943 AQUAMARINE variety of Beryl, gem quality from Mt. Princeton, Buena Vista, Colorado.
Donor: Joseph J. Cole, Jr. August, 1939.

20944 RHODOCROSITE $MnCO_3$ manganese carbonate, with galena, sphalerite and pyrite in quartz. From Alma, Colorado.
Donor: Joseph J. Cole, Jr. August, 1939.

20945 ONYX, a variety of Chalcedony, from the Knoxville Mine, near Monticello, Napa County, California.
Donor: W. C. LaRue. August, 1939.

20946 CRISTOBALITE, SiO_2 silicon dioxide in obsidian. From Little Lake, Inyo County, California.
Donor: Mrs. H. J. Hueckel. August, 1939.

20947 ILMENITE $FeTiO_3$, an oxide of iron and titanium assaying 40.8% TiO_2, beach sands from Hermosa Beach, Los Angeles County.
Donor: H. R. Smith. September, 1939.

20948 MOLYBDENITE in PYRRHOTITE. Locality: Echo Mine near Lakeside, San Diego County, California.
Donor: Chas. C. Clarke. September, 1939.

20949 PYRITE coated pebbles in conglomerate. Locality: near Roseburg, Oregon.
Donor: J. R. Wharton. September, 1939.

20950 Petrified Wood with Fossil Teredos. Locality: Near Roseburg, Oregon.
Donor: J. R. Wharton. September, 1939.

20951 BERYL Crystal, showing perfect basal termination. Location: South of Hemet, Riverside County.
Donor: Chas. Schindler. August, 1939.

20952 DUMORTIERITE, a basic aluminum borosilicate. Occurs as segregations in quartzitic schist. Shipping material averages about 53% Al_2O_3. From four miles east of Oreana, Nevada.
Donor: Walter W. Bradley. September, 1939.

20953 SCHEELITE Concentrates from the property of the Nevada-Massachusetts Co., Inc., Mill City, Pershing County, Nevada.
Donor: Ott F. Heizer. September, 1939.

20954 SCHEELITE disseminated crystals in a garnetiferous quartz in altered limestone bed. Locality: 1100 ft. level of Humboldt Mine of Nevada-Massachusetts Co., Mill City, Pershing County, Nevada.
Donor: Ott F. Heizer. September, 1939.

20955 CINNABAR (HgS). In tuff and tuff breccia, from Mogul Peak Claim, three miles northwest of Loope, Alpine County, California. (3 pieces.)
Donor: Wesley Crothers. October, 1939.

20956 ARGENTIFEROUS GALENA—from Crothers' Mine, Lexington Canyon, near Loope, Alpine County, California. (Two pieces.)
Donor: Wesley Crothers. October, 1939.

20957 VOLCANIC FLOW BRECCIA from the Jeannette Claim, Lexington Canyon, east of Loope, Alpine County, California.
Donor: Walter W. Bradley. October, 1939.

20958 SULPHUR, S, with small veinlets of CHALCANTHITE, $CuSO_4.5H_2O$, in a matrix of tuff and sulphur. From the Leviathan Mine, Markleeville, Alpine County, California.
Donor: Calpine Corporation. October, 1939.

20959 SULPHUR Crystals on a matrix of tuff and sulphur. From the Leviathan Mine, Markleeville, Alpine County, California.
Donor: Calpine Corporation. October, 1939.

20960 ROMERITE, $Fe_2SO_4.Fe(SO_4)_3.14H_2O$, hydrous iron sulphate crystals. From the Leviathan Mine, Markleeville, Alpine County, California.
Donor: Calpine Corporation. October, 1939.

20961 SULPHUR, S, in Pyrite, FeS_2. From the Leviathan Mine, Markleeville, Alpine County, California.
Donor: Calpine Corporation. October, 1939.

20962 CHALCANTHITE, $CuSO_4.5H_2O$, a hydrous sulphate of copper. From the Leviathan Mine, Markleeville, Alpine County, California.
Donor: Calpine Corporation. October, 1939.

20963 MELANTERITE, $FeSO_4.7H_2O$, a hydrous ferrous sulphate. From the Leviathan Mine, Markleeville, Alpine County, California.
Donor: Calpine Corporation. October, 1939.

LABORATORY

George L. Gary, Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one, ''Minerals of California,'' by Adolph Pabst, was published in 1938 by the Division of Mines as Bulletin 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

38. Cleavelandite, the white lamellar variety of albite, a silicate of aluminum and sodium, was present in a specimen of albite and quartz with rose-red, green and black tourmaline crystals, from Mesa Grande, San Diego County.
39. Native silver was found associated with pyrite in quartz from Mariposa County.
40. Smaltite, a cobalt arsenide, was found with erythrite in schist, from Callahan, Siskiyou County.
41. Erythrite, a hydrous cobalt arsenide, occurred as a coating with smaltite in schist from Callahan, Siskiyou County.
42. Correction: State Mineralogist's Report XXXV, January 1939, page 101, No. 15; spessarite should be spessartite.
43. Stibnite, an antimony sulphide, has been found on Frazier Mountain, Ventura County.
44. Kammererite, a peach-blossom red variety of penninite, a hydrous magnesium, iron and aluminum silicate, occurs with uvarovite as a coating on chromite, near Jolon, Monterey County.
45. Bulletin No. 113, page 238, in the three analyses of montmorillonite NA_2O, should be Na_2O.
46. Römerite, a very rare hydrous iron sulphate, occurs in brittle chestnut-brown tabular triclinic crystals in masses, and implanted on melanterite stalactites, in the Leviathan sulphur mine, about 7 miles east of Markleeville, Alpine County.
47. Chalcanthite, a hydrous cupric sulphate, occurs in groups of brittle, flattened crystals; also in massive and stalactitic forms, in the Leviathan sulphur mine, about 7 miles east of Markleeville, Alpine County.
48. Iron-copper-chalcanthite, a hydrous iron-copper sulphate, occurs in massive forms in the Leviathan sulphur mine, 7 miles east of Markleeville, Alpine County.

49. Halotrichite, a hydrous iron-aluminum sulphate occurs in white and yellowish silky fibrous growths four to five inches long and grouped together in tuft-like masses in the Leviathan sulphur mine, 7 miles east of Markleeville, Alpine County.

50. Pale-colored octahedral spinels were found in small amounts embedded in calcite at Crestmore, Riverside County.

51. Roscoelite, a hydrous potassium, aluminum and vanadium silicate was noted in sandstone from near Los Angeles, Los Angeles County.

52. Correction: State Mineralogist's Report XXXV, April 1939, page 207, No. 15—spessarite should be spessartite; No. 17—tatalate should be tantalate; No. 24—southwestern should be southeastern.

53. Scheelite, a calcium tungstate was found in small amounts associated with molybdenite, garnet and quartz in the eastern part of Amador County.

LIBRARY

John C. O'Brien, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, California Journal of Mines and Geology contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the state are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:

Topographic Maps:

Alhambra Quadrangle, Los Angeles County
Azusa Quadrangle
Bridgeport Quadrangle
Cima Mesa Quadrangle, Los Angeles County
Cucamonga Quadrangle
Dinuba Quadrangle
Fairfax School Quadrangle, Kern County
Glendale Quadrangle
Glendora Quadrangle, Los Angeles County
Mt. Whitney Quadrangle
Mt. Wilson Quadrangle, Los Angeles County
Olancha Quadrangle
Pacoima Quadrangle
San Antonio Quadrangle

San Mateo Quadrangle
Tehipite Quadrangle
Yosemite National Park
Water Supply Papers:
780 Geology and Ground Water Hydrology of the Mokelumne Area, California.
836-D Ground Water in the U. S.; A Summary.

U. S. Bureau of Mines:
Information Circulars:
7084 Mining and Milling Methods and Costs at the Black Hills Tin Co., Tinton, South Dakota, by Jos. R. Guiteras.
7085 Saving Gold by Means of Corduroy, by M. W. von Bernewitz.
7086 Testing and Design of Respiratory Protective Devices, by H. H. Schrenk.
7087 Investigation of Electrical Equipment, Safety Lamps, and Gas Detectors for Safety, by L. C. Ilsley.
7088 Changes in the Number of Companies, Plants and Kilns, and in Their Output and Capacity, by Oliver Bowles and A. T. Coons. (Graphic Survey of the Lime Industry, 1910-1938.)
7089 Formation, Collection, and Treatment of Coal Dust in Mines, by D. Harrington.
7090 Some Fundamentals of Smoke Abatement.
Report of Investigations:
3459 National Safety Competition of 1938, by W. W. Adams and T. D. Lawrence.
3460 Ocular Photocell for the Rapid Determination of Projected Area of Opaque Particles, by George T. Faust and S. R. B. Cooke.
3461 Time Study Analyses. Progress Report 1. Quarry Shovel Loading, by J. R. Thoenen and E. J. Lintner.
3462 Notes on Large-Scale Tests of the Explosibility of Coal Dusts Made in the United States and Great Britain, by H. P. Greenwald.
3463 Ignition of Firedamp by Explosives, by Bernard Lewis and Guenther von Elbe.
3464 Recent Research by the Bureau of Mines on the Ignition of Firedamp by Explosives, by S. L. Gerhard, J. C. Holtz, and Wilbert J. Huff.
3465 Methods of Rock-Dusting American Coal Mines, by J. J. Forbes.
3467 Progress Report 2. Quarry Haulage, by J. R. Thoenen and E. J. Lintner.
3468 Chemical Considerations Relating to Fires in Anthracite Refuse, by G. W. Jones and G. S. Scott.
3469 Progress Reports—Metallurgical Division. 32 Ore-Dressing Studies. Properties of Suspension Media for Float-and-Sink Concentration, by F. D. DeVaney and S. M. Shelton.
3470 Annual Report of the Mining Division, Fiscal Year, 1939. By Chas. F. Jackson.
3471 Active List of Permissible Explosives and Blasting Devices, approved Prior to June 30, 1939.
3473 Annual Report of the Nonmetals Division, Fiscal Year, 1939.
3474 Properties of a Petroleum-Reservoir Liquid and Its Residua with Applications of the Data to Production Problems, by Kenneth Eilerts, R. Vincent Smith, and Alton B. Cook.
3475 Hazard of Mercury Vapor in Analytical Petroleum Laboratories.
3478 Dust Produced By Drilling When Water Is Sprayed on the Outside of the Drill Steel.

Bulletins:

422 Metal-Mine Accidents in the United States, 1936.

U. S. Forest Service:

Maps:

Vegetation Types of California, Triumfo Pass Quadrangle.
U. S. G. S.—U. S. Relief Map.
U. S. G. S.—Oil and Gas Fields of California (1939).

Bureau of Reclamation:

Nevada and California, Showing Irrigation and Hydroelectric Development in the Truckee, Carson, Humboldt and Walker River Basins.

Books:

The Engineering Index, 1938.
The Birth and Development of the Geological Sciences, by Frank Dawson Adams.
Bibliography and Index of Geology Exclusive of North America, Vol. 6, 1938.
Examination of Placer Deposits, by Thomas A. Graves.
Energy Resources and National Policy. Report to the National Resources Committee, January, 1939.
Report of the Committee on the Measurement of Geologic Time, 1938-1939, National Research Council.
Strategic Mineral Supplies, by G. A. Roush.
Industrial Market Data Handbook of the United States, by O. C. Hollivan in Cooperation with the Bureau of Census and Bureau of Mines.
Geomorphology, by A. K. Lobeck.
The Mineral Industry During 1938, edited by G. A. Roush.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Acadamy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Conservationist, Sacramento, California.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gemmologist, London.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Sands, Clays and Minerals, Chatteris, England.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.

Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of California Journal of Mines and Geology, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of California Journal of Mines and Geology.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

Write for latest revised price list.

REPORTS

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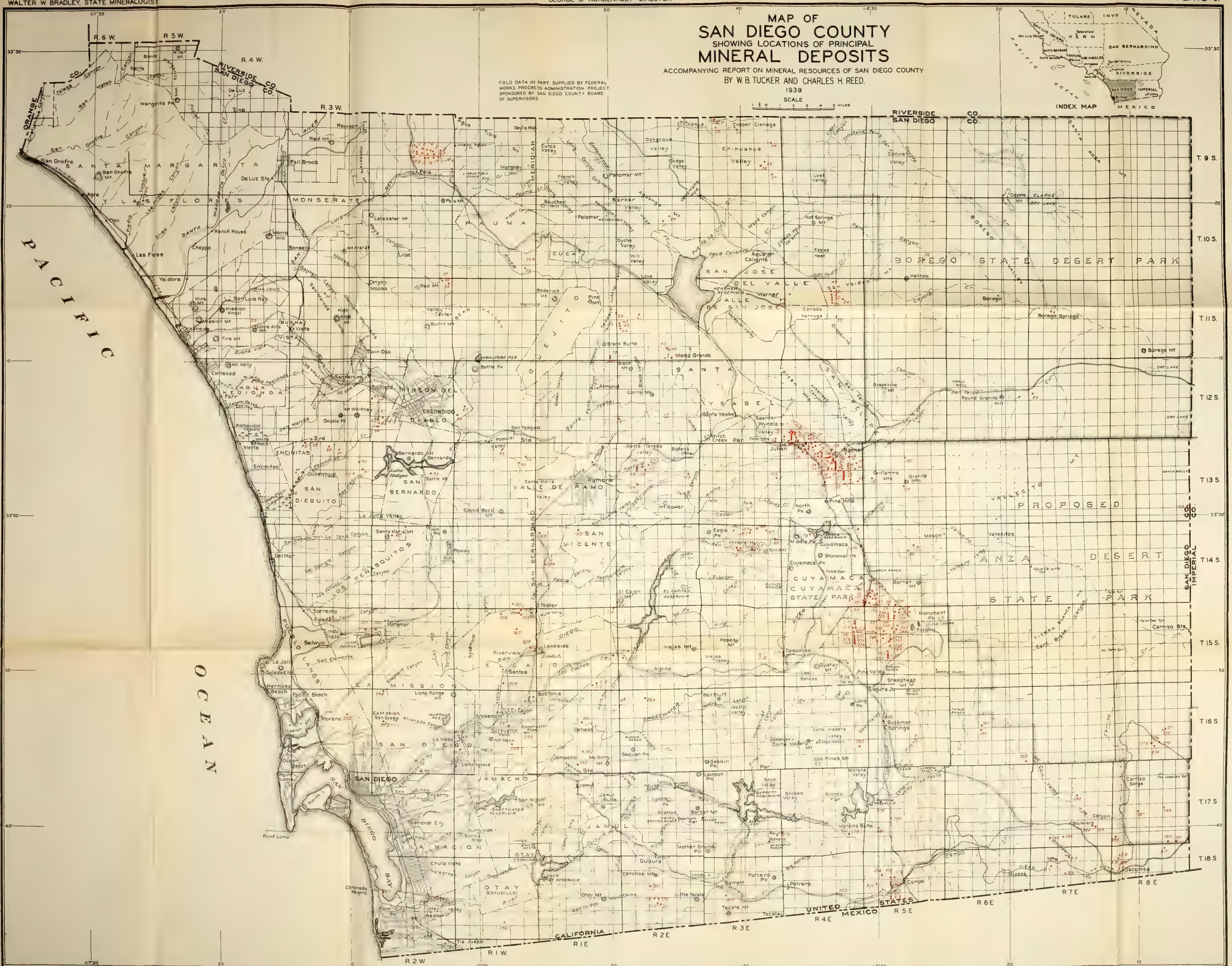
WALTER W. BRADLEY, STATE MINERALOGIST

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D. NORDENHOLT DIRECTOR

PLATE I.



MINING CLAIMS IN SAN DIEGO COUNTY

T. 9 S. R. 4 W.

No. Name

1—Whaley

T. 9 S. R. 2 W.

2—Spar King
3—Goddess
4—Pala Chief (Gems)
5—Home Stake
6—F. A. Salmons
7—Pala King
8—Green Cabin
9—Tourmaline Queen
10—Ed Fletcher Jr.
11—Tourmaline King
12—Tourmaline Queen No. 2
13—Gem Star
14—Francis
15—Douglas Claim (Gems)
16—Stewart
17—Knickerbocker
18—Sickler Mine (Gems)
19—Fargo et al

T. 9 S. R. 3 E.

20—French Pete
21—Encino
22—Maceboy Lode
23—Golden Duke
24—Blue Bell
25—?
26—Carmelita
27—Lookout Nos. 1-2-3-4

T. 10 S. R. 1 W.

28—Mack Mine
29—Big Buck (Beryl)

T. 10 S. R. 2 E.

30—Emeralite No. 2
31—Mountain Lilly Mine (Gems)

T. 10 S. R. 5 E.

32—Yellow Bar

T. 11 S. R. 4 W.

33—Crystal Silica Quarry

T. 11 S. R. 3 W.

34—Freeman Mine (Beryllium)

T. 11 S. R. 2 W.

35—Surprise No. 1
36—Surprise
37—Lead Deposit

T. 11 S. R. 1 E.

38—Esmeralda
39—San Diego
40—Himalaya

T. 11 S. R. 2 E.

41—Himalaya Consolidated Quartz Mine
42—White Quartz No. 2
43—Crystal Quartz
44—Patten Lode
45—Shenandoah Mine
46—Ida May
47—Black Eagle

T. 11 S. R. 3 E.

48—Warner's Hot Springs (Mineral Water)

T. 11 S. R. 4 E.

49—Volk Marble Deposit
50—Verruga Marble Deposit
51—Grub Stake
52—Montezuma Group
53—Lucky Strike
54—Santenac Mine
55—Marble Deposit

T. 11 S. R. 7 E.

56—Borego Springs (Mineral Water)

T. 12 S. R. 4 W.

57—Morton Clay Deposit
58—Pacific Clay Products Co. (Clay)

T. 12 S. R. 3 W.

59—Encinitas Copper Mine

T. 12 S. R. 2 W.

60—Morris Clay Deposit
61—Stockdale Granite Quarry (Ebony Black Granite Quarry)
62—Black Diamond Quarry
63—Ebony Black Quarry
64—Crystal Black Quarry

T. 12 S. R. 1 W.

65—El Diablo Lode
66—Cleveland-Pacific Mine (Gold) (Escondido Mine)

T. 12 S. R. 2 E.

67—Black Canyon Spar

T. 12 S. R. 3 E.

68—Pride of West

T. 12 S. R. 4 E.

69—Red Wing
70—Janet
71—Tom Scott
72—Owens Quarry Mine
73—Old Owens Quarry Mine
74—Roosevelt Lode
75—Chieftain
76—Van Wert
77—Ledge Lode
78—Washington
79—Eagle
80—High Park
81—Osage Lode
82—Old Ella Group
83—Majestic & Majestic No. 1
84—City of Richmond Mine

T. 12 S. R. 7 E.

85—The Narrows Mine

T. 13 S. R. 4 W.

86—Hutching Ranch Clay Deposit

T. 13 S. R. 3 W.

87—White Hawk, Ocean View and Piute Queen Lodes
88—Pearl and Dorothy (Clay)
89—Cardiff Clay Deposit
90—Greenstone (Quarry)
91—Palagonite Group
92—Carmean (Quarry)

T. 13 S. R. 2 W.

93—Bernardo Granite Quarries

T. 13 S. R. 1 W.

94—Ramona Molybdenum Deposit
95—Bour Mine (Molybdenum)
96—Bauer

T. 13 S. R. 1 E.

97—Daley Copper Mine

T. 13 S. R. 2 E.

No. Name

98—Sonny Boy
99—Beryl
100—Little Three Gem
101—Fraction
102—Surprise Mine (Gems)
103—Hercules Group (Gems)
104—Ballena Placer

T. 13 S. R. 3 E.

105—Maude

T. 13 S. R. 4 E.

106—Aguajito and Elevada
107—Sulphur Springs
108—Old Madden Group
109—Empire
110—Home Stake Group
111—Cincinnati Group
112—Kentucky Group
113—Madden Group (Gold)
114—Gem Group
115—Neptune
116—Golden Gem \#1, 2 & Big Four
117—Gardiner
118—Helvetia
119—Pine Tree Mine
120—San Diego
121—Eagle
122—Canadian Mine
123—?
124—Lucky Gene
125—Ord No. 1, No. 2 & Rocky Genes
126—Fraction & Gable
127—Gold Standard
128—Gold Cross
129—Aftermath, Boulder, Outlook, Romance, No. 11 & Sixty-two

T. 13 S. R. 4 E.

130—Banner Horseshoe
131—Banner Horseshoe Ext.
132—Ready Relief
133—Seventy-six
134—Chariot \#4
135—Chariot \#5
136—Banner Gold
137—Homestake
138—Treasure Hill
139—Poorman
140—Home Builders
141—Blue Bird
142—Ranchita
143—Gold Luck
144—Aquired & North Star
145—Sayer Graphite Mine
146—Gem \#1
147—Chariot North
148—Golden Chariot
149—?
150—Jacques
151—Golden Ella No. 1
152—Golden Ella No. 2
153—Gold Reef
154—Good Hope
165—Friday Mine (Nickel)

T. 13 S. R. 5 E.

156—Sun Rise (Manganese)
157—Royal Mine (Lithia)
158—Red Man's Granite Mountain Mine

T. 13 S. R. 8 E.

159—Consolidated Placer Mining Claim (Gypsum)

T. 14 S. R. 2 W.

160—Black Mountain Mine

T. 14 S. R. 1 W.

161—McGilvroy Raymond Granite Co.

T. 14 S. R. 1 E.

162—Mykrantz Feldspar Deposit
163—Bradley Springs
164—Woolsey Molybdenum Deposit

T. 14 S. R. 2 E.

165—El Cajon Kaolin Deposit

T. 14 S. R. 3 E.

166—Gold Crown Group (Gold)
167—Silver King
168—Coarse Gold
169—Elk (Gold)
170—Landel de (Gold)
171—Last Chance
172—Yellowstone et al
173—Pioneer Lode
174—Emma Lode
175—Lookout Group
176—Summit Group

T. 14 S. R. 4 E.

177—Oraflame Nos. 1 & 2
178—Stonewall Mine (Gold)
179—E. A. Harper

T. 14 S. R. 5 E.

180—Kane Graphite Mine (Loebrick Mine)
181—Mary Jane
182—Geo. T. Vernon
183—Telluride
184—Marguerite
185—Monawm
186—Mohawk Extension
187—Cash Entry No. 3
188—Cash Entry N
189—Tradewell No. 1
190—Tradewell
191—Cash Entry
192—Duplex & Apex North Star Annex
193—Expansion Group (Gold)
194—Margaret & Lucky Baldwin
195—Expansion Group
196—Gold Coin
197—Good Luck Mine (Gold)
198—Lillac et al
199—Fairview

T. 15 S. R. 3 W.

200—Linda Vista Clay Deposit
201—San Diego Brick & Tile Co. (Clay)

T. 15 S. R. 2 W.

202—Union Brick Company (Clay)

T. 15 S. R. 1 W.

203—Lime
204—Lakeside Lime & Marl Deposit
205—Eucalyptus Ranch Quarry
206—Rosei Quarry
207—McKoon Silver Gray Granite Quarry
208—Sand Plant
209—Covas Granite Quarry

T. 15 S. R. 1 E.

210—Lakeview Group (Iron)
211—Iron Master Group (Iron)
212—Lakeside Silica Deposit
213—Lakeside Feldspar Deposit

T. 15 S. R. 2 E.

214—Harvey Ranch (Molybdenite)

T. 15 S. R. 3 E.

215—Grand Central Quarry Mine

T. 15 S. R. 4 E.

No. Name

216—Gold Standard
217—North Star
218—Schley North & South Extension & Porphyry No. 1
219—Deer Park Limestone Deposit
220—Coinage
221—Barbara
222—Mesa
223—Sela
224—Bengal No. 1
225—Bengal No. 2
226—Barbara Worth
227—Descanso Mining Co.
228—Silent King Mine

T. 15 S. R. 5 E.

229—Ester Group (Gold)
230—Melba Group
231—Radio Lode
232—Mercedes
233—Thelma
234—Butte
235—Grace
236—Melba & Mitylene
237—Noble Consolidated Lode Cl.
238—Noble Group
239—Noble Group
240—Abbie & Louis
241—Francis Group
242—Brown Group of Claims (Gold)
243—Victoria Group (Gold)
244—Oxide Lode
245—Millsite Lode
246—Willhite Group
247—Noble Group
248—Noble Group
249—Cimarron
250—Silver Cloud
251—Gold Bug
252—Golden Harp

T. 16 S. R. 3 W.

253—Sand & Gravel (Fenton-Parker)

T. 16 S. R. 2 W.

254—Sand & Gravel (Daley)
255—Murray Canyon Gravel
256—Choyas Valley Rock & Gravel

T. 16 S. R. 1 W.

257—El Granito Mineral Springs (Mineral Water)
258—Coe Mine
259—Parson's Mine
260—Spring Valley Rock Plant
261—Orbicular Gabbro
262—Dehesa Cornwall Stone Deposit
263—Comos & Lost Peg Leg Mine

T. 16 S. R. 2 E.

264—Sillimanite

T. 16 S. R. 4 E.

265—Hoar Group of Mines

T. 16 S. R. 5 E.

266—Buckman Springs (Mineral Water)

T. 16 S. R. 6 E.

267—Winotoma
268—Crestline
269—Feldspar

T. 16 S. R. 8 E.

270—Dos Cabezas Marble Pl.
271—Limestone
272—Lime
273—?
274—Mary Jane
275—Marie

T. 17 S. R. 3 E.

276—Silica
277—Silica

T. 17 S. R. 4 E.

278—Arthur Clay Spar Mine \#1

T. 17 S. R. 5 E.

279—Star
280—Gold
281—Campo Feldspar

T. 17 S. R. 7 E.

282—Toms Dream
283—Last Chance
284—American Boy
285—Walker (Silica)
286—Marden Silica Deposit

T. 17 S. R. 8 E.

287—Overlook
288—Modern Feldspar Deposit
289—Feldspar
290—Mica Springs No. 1
291—Moore Feldspar Deposit

T. 18 S. R. 2 W.

292—Otay Gravel
293—Lime
294—Sand & Gravel
295—Sand & Gravel

T. 18 S. R. 1 W.

296—Fuller's Earth (General Petroleum Co.)

T. 18 S. R. 2 E.

297—Doolittle Group
298—Donohue Group
299—Artery Consolidated Quartz
300—Golden Artery
301—Donohoe

T. 18 S. R. 3 E.

302—Potrero Silica Deposit

T. 18 S. R. 4 E.

303—Last Chance

T. 18 S. R. 5 E.

304—Osborne Feldspar Deposit
305—Bill Hills
306—Campo Molybdenum Deposit
307—Mother Lode
308—Midway
309—Eldorado
310—Campo Iron Deposit (Iron)
311—Quality
312—Orion

T. 18 S. R. 7 E.

313—Gladden & McBean (Silica)
314—Lillian Fanning (Silica)
315—Risley (Silica)
316—Risley (Silica)

T. 18 S. R. 8 E.

317—Limestone
318—Manganese Group
319—Jacumba No. 2 (Silica)
320—Jacumba Hot Springs (Mineral Water)

DIVISION OF MINES
WALTER W BRADLEY
STATE MINERALOGIST

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
GEORGE D NORDENHOLT DIRECTOR

PLATE II.